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Relationships between Currency Carry Trade and Stock Markets

Master's Thesis

Dieu Minh Tran - 363608
Aalto University School of Business
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Author Dieu Minh Tran

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Abstract

My paper examines the relationship between currency carry trade and stock market returns. In this exercise, I analyze the effects of Japanese yen-based and US dollar-based carry trade strategies on the stock market performance of both funding and investment currencies. Currency-specific profit measure, calculated as the difference between future (realized) spot exchange rate and today forward rate, is used as a proxy for carry trade return. Using the traditional regression equation with explicitly accounting for GARCH effects in the error term, I find that: (1) there are positively significant associations between carry trade return and stock market performance in the corresponding target currency countries (Australia, New Zealand and China); (2) the relationship between carry trade and stock market returns in the corresponding funding currency countries (Japan and US) is mixed. There is negatively significant association between US dollar-based carry trade and US stock market while the relationship between yen-based carry trade and Japanese stock market is positive. My results raise a possible dispute on the role of Japanese yen as a popular choice of funding currency in carry trade transactions. However, the finding is well supported with robustness check by introducing two explanatory factors (control variables), namely market "fear gauge" VIX and Bloomberg Commodity Price indexes.

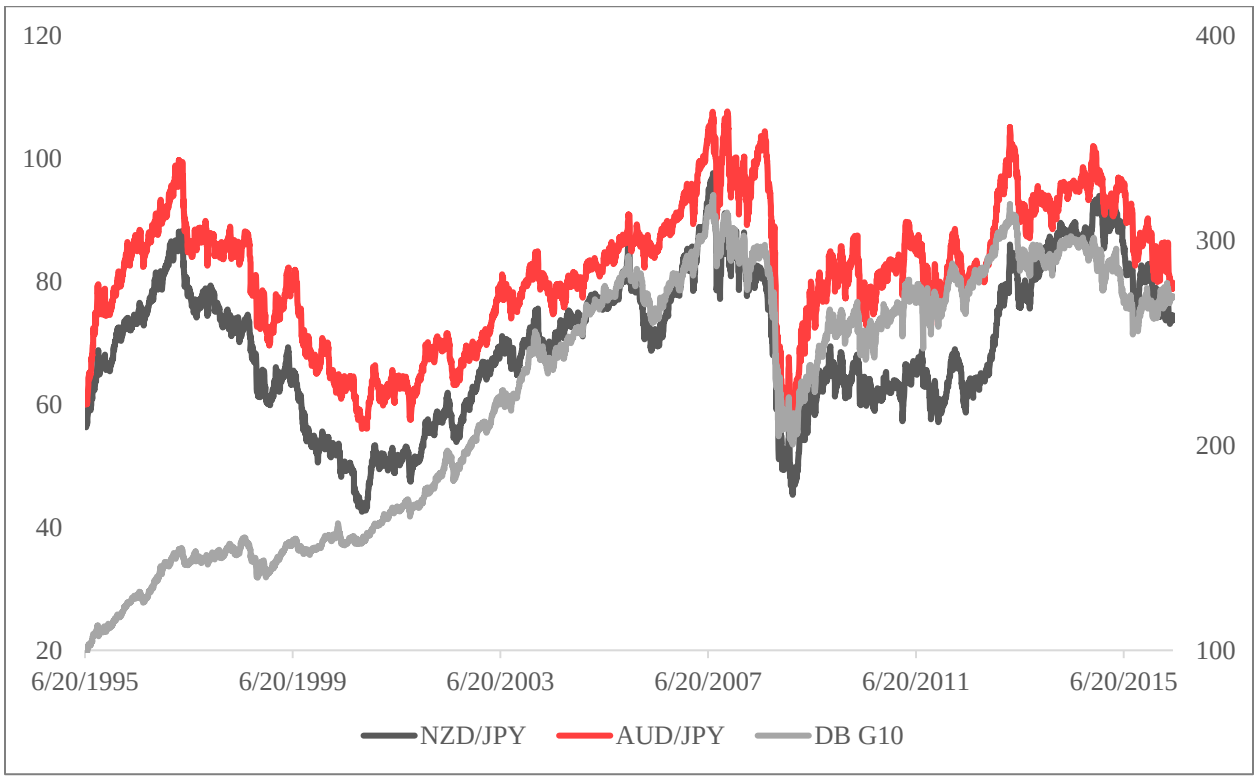
1. Introduction

On average, borrowing from low interest rate currency (funding currency) and investing proceed in high interest rate currency (investment or target currency) is profitable. This is the carry trade strategy. Under real life financial markets' trading techniques, traders sell forward currencies that are at a forward premium and buy forward currencies that are at a forward discount to earn profits. Both definitions of carry trade strategy exploit deviations from uncovered interest parity (UIP), known as "forward premium puzzle", to generate positive returns with "crash" risks associated with funding currencies. UIP states that the interest rate differential between two currencies should be offset by the expected appreciation of the low yielding currency. Carry trade investors, theoretically, cannot generate persistent returns. However, UIP generally does not hold as it has been empirically shown that currencies with higher interest rates tend to appreciate instead of depreciate.

Effectively, investors earn profit from not only interest rate differential but also investment (target) currency's appreciation over the investment horizon. For example, for the period between 2003 and 2007 when foreign exchange markets were relatively stable, there were strong appreciations of Australian and New Zealand dollars against Japanese yen that further boosted the returns from Oceanic carry trade strategies. Carry trade investors, however, only enjoyed these favorable exchange rate movements in low volatility periods. In time of financial turmoil, such as global crisis 2008, the carry trade experienced large unwinding in trading positions where investors reversed money flows out of Japanese yen, which had been widely used as a funding currency because of low interest rate environment in Japan. The reversal activities unintentionally inflated the yen while depressing other high yielding currencies at that time. As a result, investors suffered huge losses since the damage from unfavorable exchange rate movements out-weighted gains from interest rate differentials. Therefore, carry trade performance largely depends on financial markets' volatility or investors' risk sentiments. Figure 1 illustrates the relationship between Australian (New Zealand) dollar exchange rate movements and Deutsche Bank's DB G10 Currency Harvest index. The index, widely used as a proxy for carry trade return performance, is a portfolio that composes of a long position in the three highest yielding currencies and a short position in the three lowest yielding currencies out of G10 currencies (US dollar, euro, Japanese yen, Canadian dollar, Swiss franc, British pound, Australian dollar, New Zealand dollar, Norwegian krone and

Swedish krona). The figure clearly shows high correlations between the Oceanic currencies and carry trade performance, especially since the start of 2000.

Figure 1: AUD & NZD Movements versus Carry Trade Returns



There is no shortage on studies that have examined risk factors explaining the average positive returns from carry trade strategies. Brunnermeier et al. (2009) introduced "crash" risk that carry trade investors are exposed to. They conjectured that large exchange rate movements without any specific news can be due to the sudden unwinding of carry trades when speculators near funding constraints. For example, figure 2 depicts a specific case on October 7 and 8, 1998 when there was a considerable drop of US dollar against the yen due to a sudden unwinding of carry trade activities. In addition, investment currencies are subject to crash risk, thereby significantly depreciating values in these periods. Burnside et al. (2009) concluded that the returns are uncorrelated to standard risk factors, attributing instead to market frictions such as bid-ask spreads, price pressure and time-varying adverse selection. Although there have been many papers focusing on risk factor understanding, studies on relationship between carry trade and other asset classes on international financial markets are limited. Therefore, my paper aims to explore currency carry trade from this perspective and focuses on the equity stock returns of both funding and investment currencies. In

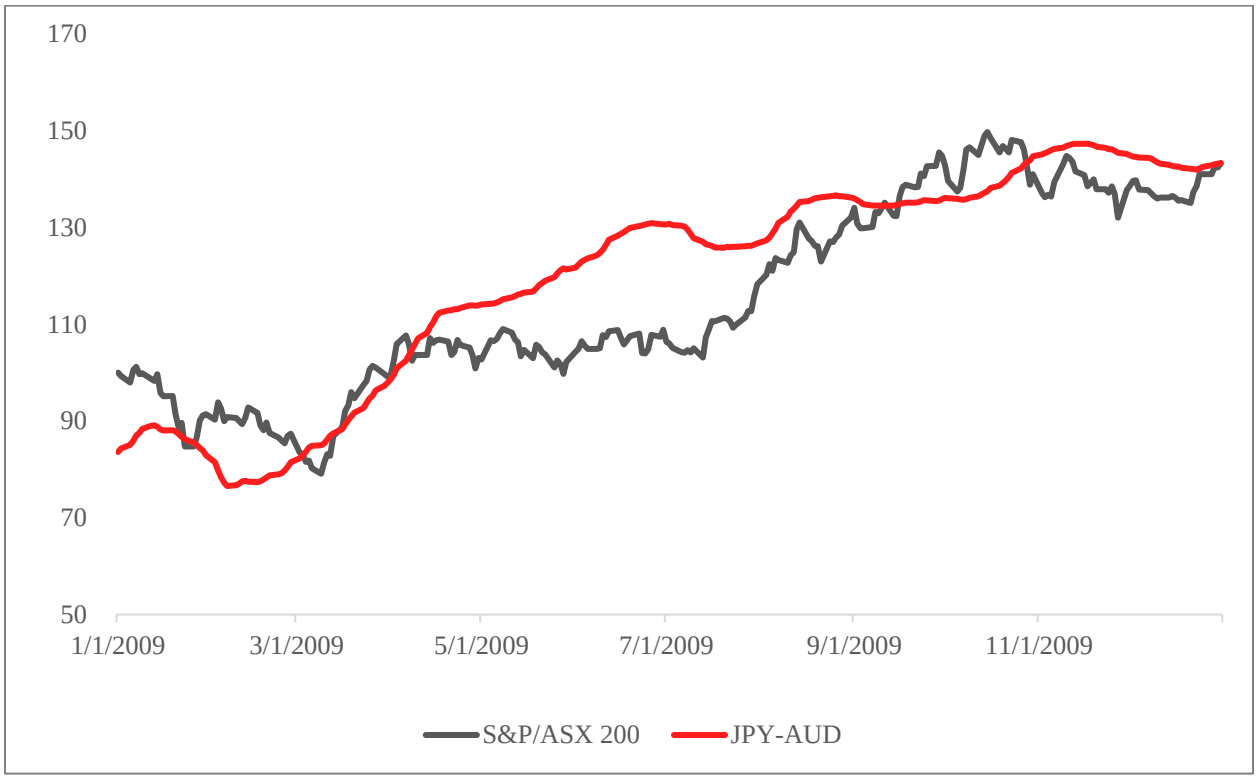
fact, the relationship between carry trade and stock market have been well supported by some historical evidences.

Figure 2: Sudden Drop of US Dollar Exchange Rate against Japanese Yen

As mentioned earlier, the popular yen carry trade experienced a large unwinding in the aftermath of the turmoil occurring in 2008-2009 crisis. The reversal of carry trades amidst the crisis were sources of yen strength which put investors into significant losses due to the appreciation of funding currency out-weighting benefits from interest rate differential. Concurrently, the unwinding overlapped the fall in the US stock market. A possible explanation for this overlapping lies with investors' risk appetite. During the period of extreme market turbulence, many investors preferred to turn their targeted investments into safe-haven assets such as yen or US Treasury bonds, thereby reducing demands and liquidity in the markets of riskier assets, specifically US stocks. Stock market, as a result, suffered capital outflows and fell. Such overlapping, but with reverse direction in market movement, also happened in the post crisis period. By the end of March 2009 when global equity markets, including the US stocks, rebounded, yen carry trade began showing signs of recovery. In the entire year of 2009, the popular yen-Australian carry trade gave an impressive return of 40 percent due to robust appreciation of Australian dollars against Japanese

yen. Moreover, Australian stock market, as measured by S&P/ASX 200 stock market index, also climbed more than 40 percent over the same period that further corroborates the relationship between the two markets. Figure 3 graphs the outstanding performance of both stock and currency carry trade markets in 2009. JPY-AUD is a carry trade strategy that use Japanese yen and Australian dollar as funding and investment currency, respectively. The return of this strategy is calculated by applying equation (1) as detailed in section 3. As can be seen from the figure 3, the returns of both Australian equity market and JPY-AUD carry trade move in a tandem with an upward trend in 2009, which illustrates an evidence of possible interconnection between the two markets.

Figure 3: Co-movement between Australian Equity and Carry Trade Returns



Note: JPY-AUD is carry trade strategy using JPY and AUD as funding and investment currency, respectively.

It is important to understand the mechanism that carry trade causes exchange rate swings and possible transitional effects on other asset classes, specifically equity stock markets in this paper, through the so-called liquidity "push channel". Firstly, the interest rate differential between two currencies generates carry trade temptations among investors. They then participate in the strategy, which effectively creates an excess supply of funding currency and an excess demand of the

investment currency. The investment currency, as a result, appreciates against its funding currency due to the imbalance between supply and demand. Reversely, carry trade unwinding as discussed above spurs exchange rate swings in the opposite direction. Push channel explains liquidity movements across different asset classes. Generally, investors who borrow money in low interest rate currencies invest the proceeds into higher-yielding assets such as other currencies (known as carry trade strategy) or stock markets. These activities increase liquidity in the target investment markets and lead to asset price inflations. Therefore, return in one market, for example carry trade, is related to the other, for example stock market. This anticipation encourages me to conduct deeper research into the dynamic relationship between currency carry trade and its related equity stock markets.

In this paper, I look into the contemporary movements between carry trade and stock market returns. Specifically, the study examines the effects of currency carry trade activities on the stock markets. I included the market indexes from both funding and investment currencies in order to compare the effects across different types of equity markets, which is slightly different from prior literatures that only focused on target currencies' stock markets. In my study, a basket of two funding currencies (Japanese yen and US dollar) and three investment currencies (Australian dollar, New Zealand dollar and Chinese renminbi) was used to form six carry trade strategies including (funding - investment currency): Japanese yen - Australian dollar (JPY-AUD), Japanese yen - New Zealand dollar (JPY-NZD), Japanese yen - Chinese renminbi (JPY-CNY), US dollar - Australian dollar (USD-AUD), US dollar - New Zealand dollar (USD-NZD) and US dollar - Chinese renminbi (USD-CNY). My paper solely focuses on the effect of each carry trade strategy, rather than the effect of a portfolio of multiple strategies, on equity stock market performance; therefore, the proxy of carry trade performance which is built on a combination of different carry trade strategies could be implemented in the future as one of the improvements for my research topic.

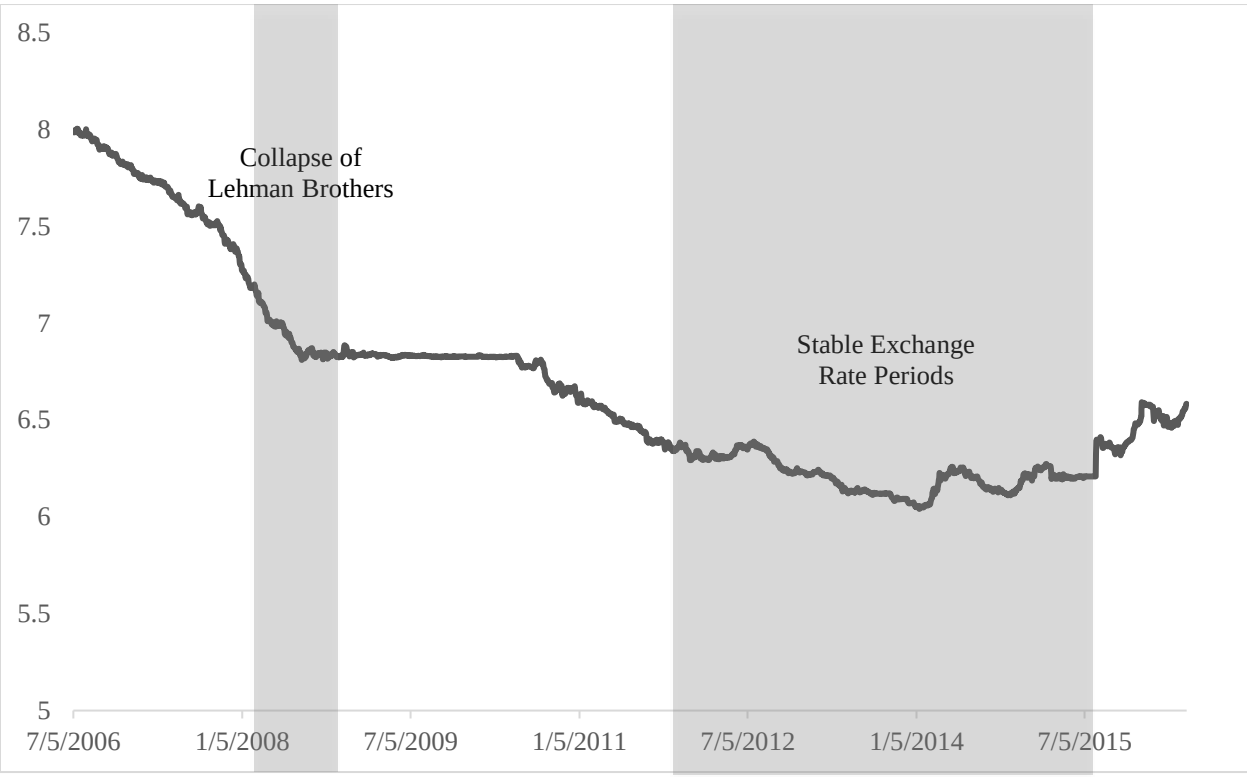
During and after the "Lost Decade" in Japan, the country's financial markets have widely been known to be supported by the massive quantitative and qualitative easing programs (QQE), which effectively create a very low interest environment, making it a potential source for financing carry trade transactions. Similarly, global financial crisis of 2007-2008 also forced US to adopt a low interest rate policy in order to boost growth and recover its economy. When the Federal Reserve

(Fed) cut interest rates to zero in 2008, it flooded the system with the US dollars. Therefore, a global reserve currency was considered as a best option to borrow for carry trade financing, especially in the post crisis period. On the other hand, Australian and New Zealand markets have been characterized as high interest rate environments with 10-year government bond yields approximating 7% before crisis (see figure 4). Chinese renminbi was opted in my exercise due to the fact that, in addition to the country's high interest rate, China held its currency stably fixed at about 6.2 - 6.5 to the dollar, making it a good candidate for investment currency in carry trade. Figure 5 shows a significant appreciation for renminbi exchange rate that allows it to become an investment currency for carry trade transactions. Therefore, the above rationales help me develop six carry trade strategies from a basket of two funding currencies and three investment (target) currencies.

Figure 4: 10-year Government Bond Yields

Note: Chinese 10-year Government bond yield is not included in the graph due to its unavailability.

Figure 5: Renminbi Exchange Rate Development (RMB/$)



For each currency pair or each trading strategy, there are two corresponding equity stock markets that were used as dependent variables in the regression equations. As a result, six equity stock market indexes were considered in this exercise including Japanese Nikkei 225, US S&P 500, Australian S&P/ASX 200, New Zealand S&P/NZX 50 and Chinese SHASHR. In this paper, I examine whether an increase (or decrease) in carry trade return affects the returns of its corresponding stock markets by using regression equation with explicitly accounting GARCH effects in the error term. For the purpose of robustness, I include a few control variables in my analysis such as measure of investors' fear gauge VIX and Bloomberg Commodity Price indexes. As a proxy for market volatility, VIX is a relevant factor that affects returns of both carry trade and stock markets. The inclusion of commodity price index is motivated by the fact that some countries in my paper, for example Australia and New Zealand, have been well known for commodity trade. Thus, commodity prices could affect the stock market performance of these countries.

My work contributes to existing literature that have been looking for relationship between carry trade and equity stock market. As mentioned earlier, most of carry trade-related papers are

searching for global factors pricing the return to the carry trade; hence, a different focus in my paper provides some new insights into carry trade topic. In addition, I include the US dollar as a funding currency and Chinese renminbi as an investment currency, which are hardly seen in prior work as possible currency options for carry trade transactions. The inclusion of the US dollar, in addition to Japanese yen as a funding currency, also provides an interesting result about the difference in the relationship between US dollars-funded and yen-funded carry trade with their corresponding stock markets (S&P 500 and Nikkei 225). Finally, previous papers on the relationship between two markets, for example Cheung et al. (2012) and Tse et al. (2012), might be assimilated to my study; however, I differ to their papers by including equity stock markets of both funding and investment currencies.

My work is not without limitations. One of notable limitations is that my regression model does not include a proxy for volatility transmission across different asset classes. Volatility in financial markets is believed to affect investors' buying and selling decisions, thereby contributing to returns of carry trade and stock markets. Although VIX is incorporated in the equation for robustness check, it does not provide a clear picture of volatility transmission across different markets. Secondly, there are several ways to execute a carry trade for example via forward contracts, future contracts or simply borrowing one currency and investing in another. Therefore, different proxies for carry trade returns should be considered in order to have reliable evidence on carry trade effects; however, my paper only has profit measure of difference between forward exchange rate and future spot rate as a proxy for currency carry trade return. Although there are some limitations in the current exercise, the inclusion of robustness check makes my empirical results more plausible.

The paper is organized as follows. Section 1 is for this introduction. Section 2 reviews prior research on carry trade and its relationship with stock market. Section 3 explains data and provides preliminary descriptive summary for carry trade and stock market returns. Section 4 introduces methodology and the study hypotheses while the results and analyses are presented in Section 5. Section 6 makes some concluding remarks.

2. Literature Review

2.1 Explaining Carry Trade Returns

Uncovered Interest Parity (UIP) is a parity condition stating that currencies with higher interest rates should depreciate against those with lower interest rates. It effectively implies the difference in interest rates between two countries equals to the expected change in exchange rates between two countries' currencies; as a result, carry trade investors cannot generate persistent profit from their strategies. However, empirical results suggest otherwise. Carry trade strategies, on average, brought in positive excess returns.

The literature identifies two sources of profit for carry traders. Cavallo (2006) explained the two sources in details: Firstly, the profit of the strategy is proportional to the interest rate differential between funding and investment currencies if the exchange rate between the two currencies does not move. Secondly, as the exchange rate varies due to supply and demand forces in foreign exchange (FX) market, the second source for carry trade comes from the favorable exchange rate movements, i.e. the appreciation of investment currency against funding currency. However, if the reverse scenario happens, the loss due to unfavorable exchange rate movements can sometimes offset the gain from interest rate differential, thereby resulting in negative returns for carry trade strategy. Especially, the profitability of carry trade declined significantly due to funding currency's substantial appreciation in periods of crisis, as shown in Briere and Drut (2009) and Brunnermeier et al. (2009).

Darvas (2009) studied all possible currency pairs from 11 major currencies for a period between 1976 and 2008 (before crisis) and found that the strategy was significantly profitable in the absence of leverage. The author also cited the trade-off presence of leverage, i.e. boosting the returns but magnifying the downside risks. Hansen and Hodrick (1980) and Fama (1984) provided evidence in their work that higher interest rate led to further appreciation of the currency, instead of depreciating it. In addition, authors also pointed out another impressive finding that investors were able to earn high returns by holding bonds denominated in high interest rate currency, implying a failure of UIP in the past. Bilson (1981), to some extent, also confirmed the invalidity of UIP by concluding that the future spot rates have been closer to current spot rates than to current forward rates during the current floating rate period. Specifically, he attributed the results to market inefficiency, influence of risk premium, transaction costs and information costs on the value of

forward premium. After a period of testing a validity of UIP, the focus shifted to explaining the returns by exploiting deviations from UIP, i.e. carry trade. Noticeably, traditional risk explaining factors such as stock market excess returns, consumption growth, term premium or Fama and French (1993) factors have not consistently explained carry trade returns.

Burnside et al. (2011) studied the properties of the carry trade and found that the strategy generated high average payoff which were uncorrelated with conventional risk factors. Instead, the authors cited an underlying "peso problem", i.e. low-probability events that do not occur in the sample, as a contributor to the large return. Assuming the foreign currency is trading at forward premium, i.e. the currency is expected to depreciate in the future; investors would sell the foreign currency forward. Given the failure of UIP, foreign currency might appreciate which results in losses to investors' positions. Therefore, they are compensated in the form of high carry trade profits. Menkhoff et al. (2012) investigated the relationship between global foreign exchange (FX) volatility risk and the excess returns arising from the carry trade. The authors also found that high payoff from the strategy was a form of compensation for global FX volatility risk borne by investors. Moreover, liquidity risk contributed, albeit to a lesser degree, to the excess returns. Liquidity risk is also presented in Dobrynskaya (2014) as an explanatory factor for the carry trade return. She emphasized on the global downside market risk of currency that compensates for the positive return.

One of the consequences of the zero rate and aggressively easing monetary policy in Japan was the emergence of massive yen (JPY) currency carry trade activities. Yen-funded carry trade empirically generated persistently high returns; however, the strategy exposed traders to large currency risk and huge losses if the Japanese currency were to appreciate substantially. As highlighted by Gyntelberg et al. (2007), the annualized average daily return on the Australian dollar/yen carry trade was 12.5 percent per year during the period 2001 to September 2007, compared to only 3.6 percent for the S&P 500 index. In addition, the strategy currency risk was reflected through negative skewness, indicating a higher frequency of large negative returns. The negatively skewed characteristics were most pronounced with respect to Australian (or New Zealand) dollar/yen carry trade. This attribute was also briefly discussed in the above-mentioned Brunnermeier et al. (2009). In their paper, the authors termed it as "crash" risk and confirmed the presence of the negative skewness due to rare occasion of unexpected negative shocks to the

liquidity in financial markets. They believed carry trade investors were compensated with positive gains because of the "crash" risk associated with the funding currencies, for example Japanese yen.

2.2 Relationship between Carry Trade and Stock Markets

Prior to my work, there are only few studies that investigate the relationship between currency carry trade and stock markets. These studies mainly focused on the cross-market predictive power, which means whether an increase (or decrease) in one market return is able to predict the performance of other market, and volatility spillover effects. The mixed results have been reported across some papers as below.

Tse et al. (2012) examined the connection between carry trade and the US stocks from January 1995 to September 2010. Similar to Deutsche Bank's DB G10 Currency Harvest Index, the study considered the portfolio that include a long position in the currency with highest interest rate and a short position in the currency with lowest interest rate as a proxy for carry trade performance. The US stock market was represented by the futures contracts on the S&P 500 index, which were traded on the Chicago Mercantile Exchange (CME). The authors used vector auto regression (VAR) model to examine the causal relationship in returns between two investment asset classes. They found that carry trade returns could not predict future US stock market returns, and vice versa. However, when using GARCH model to identify volatility spillover process from one market to another market, a significant volatility transmission from stock market to carry trade market, but not in reverse direction, was observed. The result supports the explanation from Engle et al. (1990) that information flowing from the stock market to the carry trade market triggers investors, who have heterogeneous interpretations on the information, to revise their beliefs and start trading.

Fung et al. (2013) extended the study of Tse et al. (2012) by considering Asian countries in their analyses. Specifically, the authors used the data from January 1995 to December 2011 to evaluate volatility spillovers between currency carry trade and stock markets from Japan, Australia, India and Korea. Moreover, three different carry trade's currency baskets were constructed including DB G10 currencies, major Asian currencies (Indian rupee, Indonesia rupiah, Malaysian ringgit, Philippine peso, Singapore dollar, South Korean won, Thai baht and Taiwan dollar) and a combination between DB G10 and major Asian currencies. These baskets formed three proxies for

carry trade returns. Futures contracts on the above-mentioned four stock markets were used in their analyses. By employing similar econometric techniques as in Tse et al. (2012), the authors found significant Granger causality from carry trade returns (based on DB G10 currency basket) to Japanese, Australian and Indian stock markets. It implies that higher carry trade returns led to the improving performance of stock markets, which was explained as a consequence of capital flows from funding currency's to investment currency's financial markets. However, when the return of the US stock market is included as for robustness check purpose, the significance of causal relationships only hold with respect to Japanese and Australian stock markets. In addition, they provided an interesting result that Japanese yen no longer played the common role of a funding currency in carry trade. The authors postulated that global carry trades, indeed, participated in betting on the strong economic fundamentals in Japan, thus allowing the Japanese stock market with low interest rate environment to become a target for carry trade investment and attract capital flows. Finally, the cross-market volatility spillover effect was investigated with GARCH model. Despite a more pronounced volatility transmission from stock to currency carry trade market during the financial crisis, the reverse direction in which the spillovers started with carry trade market was noticeably observed in post crisis period.

Another related study, with the data ranging from January 2001 to October 2008, was conducted by Cheung et al. (2012). Their paper examined the implications of a popular yen-funded carry trade for stock markets in target currency countries. The target currencies used in their work included Australian dollar, British pound, Canadian dollar, New Zealand dollar and Mexican peso. Their respective stock indexes, namely All Ordinaries, FTSE 100, S&P/TSX Composite, S&P/NSX 50 and IPC, were considered to track the performance of equity stock markets. Moreover, the authors used three alternative proxies for carry trade activity including currency-specific profit measure, currency-specific futures position and DB G10 Currency Futures Harvest index. Regarding methodology used in the paper, they employed the regression equation with accounted GARCH effects in the error term. It was reported that the above-mentioned proxies for carry trade exhibited various degrees of positive impacts on target currency stock market returns, even with the presence of some control variables such as the US stock return, the VIX index that represents financial market volatility and the commodity prices. My paper follows Cheung et al. (2012) paper's currency-specific profit measure in order to build the proxy for carry trade performance. The proxy is explained in detail in Section 3.

Lee et al. (2013) examined the cross-market linkage between spillovers of currency carry trade returns and the US market returns. Similar to Tse et al. (2012), the authors used DB G10 currencies and S&P 500 index futures in order to assess the impact of currency carry trade market on stock market and vice versa. They constructed the total spillover index for currency carry trade returns and used it to measure the degree of market risk sentiment. With data covering a period from January 1994 to March 2012, the authors found a higher magnitude of spillovers in bull markets than in bear markets. This finding was consistent with Frijns et al. (2008) as they suggested when the market is bullish, investors are more willing to invest in risky assets. Furthermore, Lee et al. (2013) also showed a significantly positive relationship between spillovers of currency carry trade returns and subsequent market returns. Specifically, constructed spillover index Granger-caused the returns of stock market but not vice versa. The results, as suggested by the generalized VAR framework and Markov-switching models, also indicated that a stronger relationship was observed in bear markets than in bull markets. This paper is also the first one to look on the influence of spillover effects of carry trade returns on equity stock market performance under both bull and bear market regimes. Table I below summarizes related literatures looking for relationship between carry trade and stock market performance.

Table I: Carry Trade versus Stock Market – Literature Review

	The Relationship between Currency Carry Trades and US Stocks	*Are Stock Markets in Asia Related to Carry Trade?*	*Yen Carry Trades and Stock Returns in Target Currency Countries*	*Spillovers of Currency Carry Trade Returns, Market Risk Sentiment and US Market Returns*
Authors	• Yiuman Tse, Lin Zhao	• Hung-Gay Fung et al.	• Yan-Leung Cheung et al.	• Hiu-Chuan Lee et al.
Overview	• Examines the possible relationship between daily returns of currency carry trades and the US stocks market (Jan 1995 - Sep 2010)	• Examines the cross-market linkage between two markets (Jan 1995 – Dec 2011) • Evaluates the volatility spillover effect for some Asia stock markets	• Examines and analyze the implications of yen carry trade for stock markets in a few selected target currency countries (Jan 2001 – October 2008)	• Examines the linkage between spillovers of currency carry trade returns and the US market returns (Jan 1994 – March 2012)
Data & Methodology	• Proxy for carry trade daily excess returns are obtained from DB G10 Currency Harvest index • VAR model (Granger Causality) and Bivariate EGARCH (1,1)-t model	• Carry trade return is proxied by an investment portfolio with long (short) positions in 3 highest (lowest) yielding currencies out of G10 currency basket	• Three alternatives for carry trade activity namely currency specific profit measure, currency specific futures and DB G10 Currency Harvest are used	• Carry trade daily excess returns are obtained from DB G10 Currency Harvest index • Generalized VAR, Markov-switching VAR model are used to

	are used to identify the relationship	• VAR and CCC-GARCH (1,1) models are used	• Simple regression is estimated (explicitly accounting for GARCH effects)	examine the spillover effects
Results	• Carry trade and stock markets are highly correlated with no Granger causality • There is significant volatility spillovers flow from stock market to carry trade market • Markets are more correlated in periods of high volatility	• There is significant causality from carry trade to Asian stock markets, i.e. carry trade returns can predict stock market performance • Bidirectional volatility spillover effect is found (stock market to carry trade and carry trade to stock market) • Carry trades also participate in betting on economic fundamentals	• Three measures display various degree of influences on stock market returns • Result is also robust with inclusion of three additional control variables (US stock market, VIX index and commodity prices)	• There is a significantly positive relationship between spillovers of currency carry trade and subsequent stock market returns • This relationship is found to be stronger in bear markets than in bull markets • Spillovers significantly affect the subsequent transition probabilities of market returns

3. Data

3.1 Carry Trade

The literature highlights a variety of research papers looking into carry trade and its related topics such as risk factors and cross-market linkages. This paper focuses on the latter issue, i.e. the cross-market relationship between carry trade return and stock market performance. As explained earlier, carry trade strategy exploits the failure of the uncovered interest parity (UIP); therefore, carry trade return could be derived by starting with covered interest parity condition and applying expectation operator to reflect uncovered parity condition. A detailed derivation of carry trade return's formula is given in the Appendix A. Basic result for carry trade return by using currency specific profit measure is as following:

$$\pi_{t+1} = e_{t+1} - f_{t,t+1}, \tag{1}$$

where π_{t+1} is the carry trade profit by conducting the strategy that starts at time t and ends at time t + 1. Indeed, π_{t+1} is also known as the deviation from UIP. e_{t+1} is the spot funding currency (Japanese yen or US dollar) exchange rate per a given target currency (Australian dollar, New Zealand dollar or Chinese renminbi) in logarithmic at time t + 1. $f_{t,t+1}$ is logarithmic one period forward exchange rate at time t. From (1) we know that the excess return is the same as the forward rate bias, i.e. the difference between the forward rate at time t and the spot rate at time t + 1. In order to execute carry trade, investors enter futures market with a long position in high yielding target currency forward at $f_{t,t+1}$. If a realized spot rate at time t + 1, e_{t+1}, is higher than the forward rate purchased at time t, then the carry trade generates profit. In this paper, the return π_{t+1} is based on one-month forward period. Generally, this currency specific profit measure exploits the momentum or the feedback mechanism that drives the success of carry trade, as discussed in Jorda and Taylor (2009).

Data of spot and one-month forward exchange rate for target currencies (as quoted in funding currency Japanese yen or US dollar) were retrieved from DataStream. The data almost covers a ten-year period ranging from July 5, 2006 to May 31, 2016. After collecting necessary data, I applied formula (1) in order to calculate the returns for six different carry trade strategies, including (funding - investment currency): Japanese yen - Australian dollar (JPY-AUD), Japanese yen - New Zealand dollar (JPY-NZD), Japanese yen - Chinese renminbi (JPY-CNY), US dollar - Australian

dollar (USD-AUD), US dollar - New Zealand dollar (USD-NZD) and US dollar - Chinese renminbi (USD-CNY). For each pair currency carry trade, there are two corresponding stock markets that are funding currency and investment currency stock markets.

Figure 6: Daily Carry Trade Cumulative Returns (July 5, 2006 = 100)

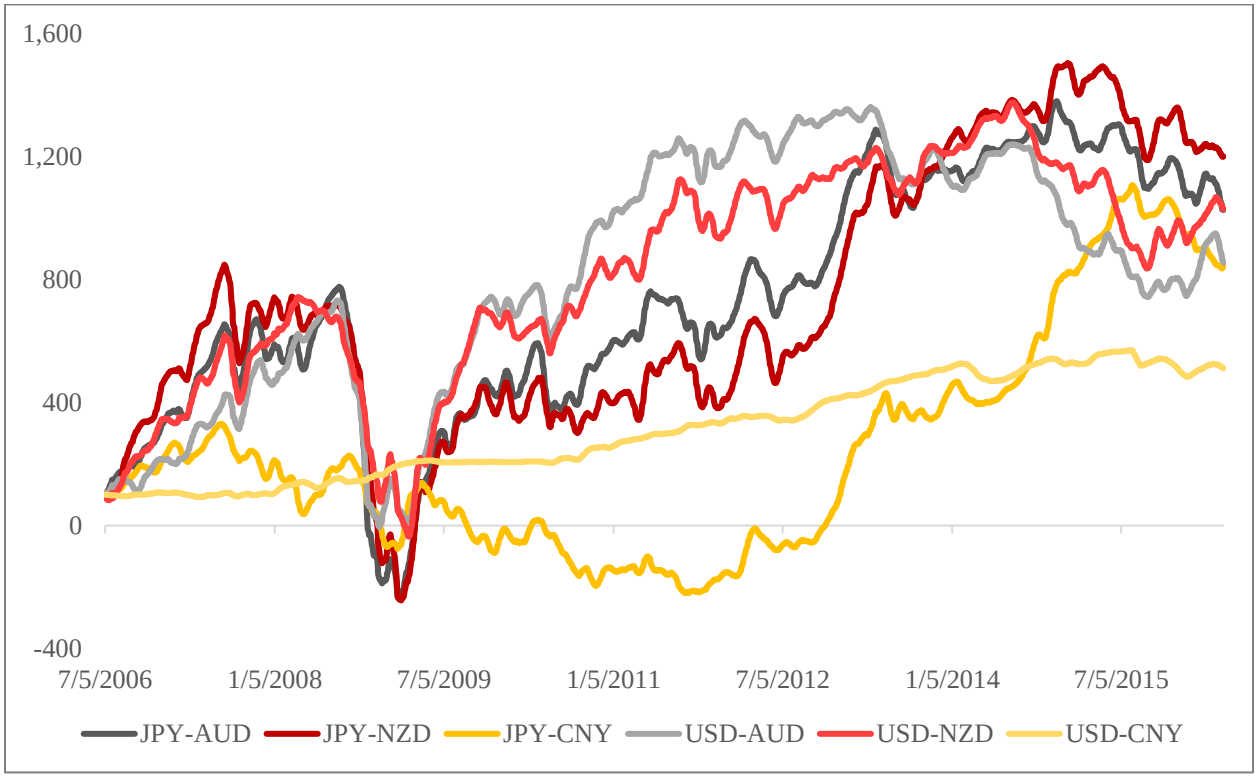


Figure 6 highlights the performance of six carry trade strategies. Four out of six carry trades (except JPY-CNY and USD-CNY) shared a same trend over the last ten-year period. Their performance suffered the devastating 2008 financial crisis before regaining ground in 2009 and fully recovering due to impressive appreciations of some investment currencies such as Australian dollar and New Zealand dollar. To some extent, a strategy which used Japanese yen as funding currency and Chinese renminbi as investment currency also followed a similar path; however, the damaging effects of the crisis on the strategy was smaller but longer than the others. Moreover, JPY-CNY recovered at the fastest pace starting from 2012 as Chinese renminbi strongly appreciated against the yen at more than 36 percent for the period between July 5, 2006 and May 31, 2016. Generally, carry trade strategies exhibited outstanding performance in my examined window especially after in the post crisis period when the global financial markets became less volatile and more stable.

Although there are some differences in cumulative returns of six carry trades, these strategies all shared few similar characteristics. Table II provides summary statistics of daily carry trade returns, which are calculated by applying the equation (1) as mentioned above. On average, all six carry trade strategies have positive mean and negative skewness. The results are consistent with findings by Brunnermeier et al. (2009). The authors stated that the carry trade was averagely profitable but also has crash risk (as measured by negative skewness) and fat tails (as measured by positive kurtosis). Particularly, negative skewness as observed from the six carry trades represents a higher probability of significant losses due to investors' currency carry trade positions, i.e. a short position in funding currencies that tend to appreciate and a long position in investment currencies that tend to depreciate during turbulent periods. Moreover, these six carry trade strategies show a various degree of correlation, as illustrated in table III. It is under my expectation that there are high correlations between the Oceanic carry trades, namely JPY-AUD, JPY-NZD, USD-AUD and USD-NZD. Australia and New Zealand have shared several common characteristics such as similar geographical location, high benchmark interest rate and commodity-based economy, which allows their currencies to move in tandem for years. During my studied period, their two currencies exchange rates have a correlation of over 90 percent. As a result, the Oceanic-based strategies perform significant degree of interconnection. In addition, strong correlations are also founded among Japanese yen-funded strategies, which include JPY-AUD, JPY-NZD and JPY-CNY. This finding can be partly explained by high degree of correlations between Australian or New Zealand dollar and Chinese renminbi, 51% and 77% respectively. The similarity in carry trade dynamics is also likely to be driven by the similarities in institutional characteristics, which requires further investigations to fully understand the strategies' behaviors.

Table II: Summary Descriptive Statistics of Carry Trade Returns

Statistics	**JPY-AUD**	**JPY-NZD**	**JPY-CNY**	**USD-AUD**	**USD-NZD**	**USD-CNY**
Mean	0.0035861	0.0042595	0.0028763	0.0015902	0.0035940	0.0029204
Max	0.1507	0.2077	0.0982	0.0232	0.1877	0.1307
Min	-0.3864	-0.3184	-0.1145	-0.0301	-0.2197	-0.2877
Std.	0.0474001	0.0483191	0.0269115	0.0057441	0.0390532	0.0385684
Skewness	-1.553314	-0.8864666	-0.0721561	-1.060456	-0.4494102	-1.060189
Kurtosis	10.49637	6.397154	3.724858	7.432481	5.204503	7.815613

Table III: Carry Trade Returns Correlation

Correlation	JPY-AUD	JPY-NZD	JPY-CNY	USD-AUD	USD-NZD	USD-CNY
JPY-AUD	1.0000					
JPY-NZD	0.8861	1.0000				
JPY-CNY	0.5984	0.5940	1.0000			
USD-AUD	0.8130	0.6673	0.0564	1.0000		
USD-NZD	0.6855	0.8209	0.0644	0.8265	1.0000	
USD-CNY	0.1161	0.0947	0.1452	0.1611	0.1353	1.0000

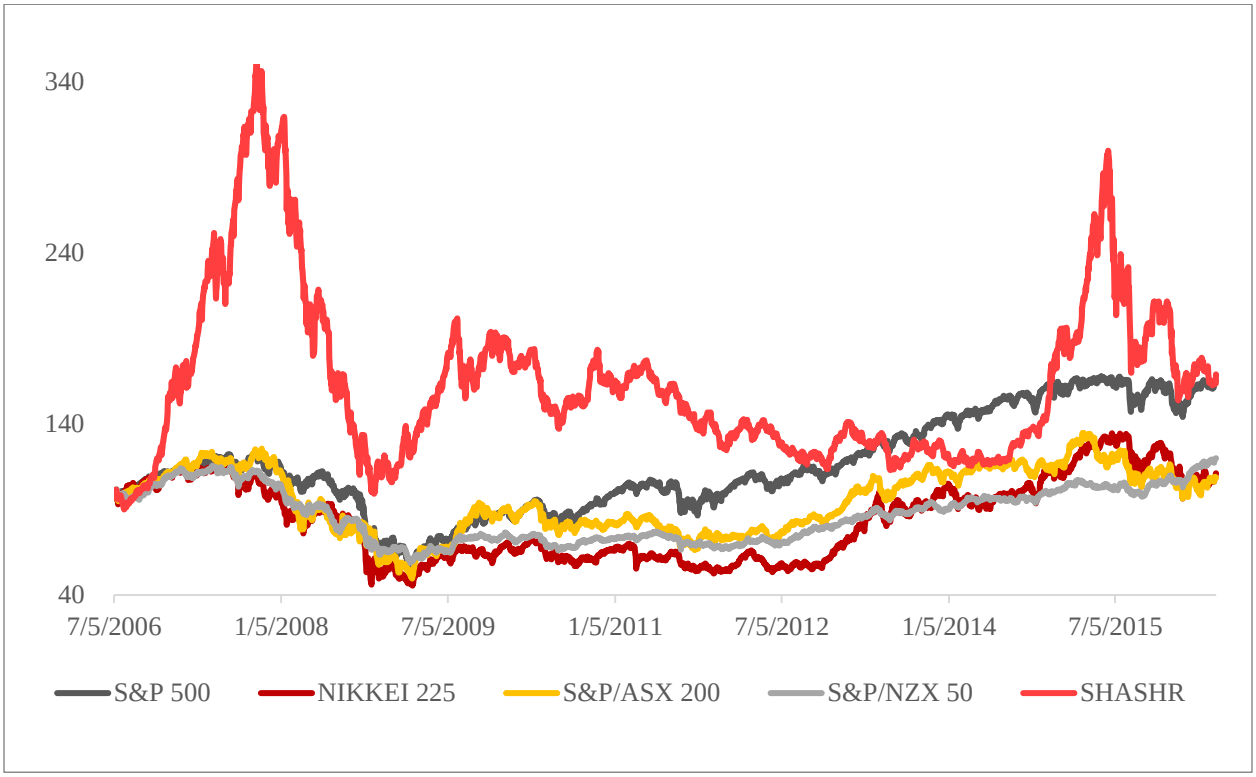
3.2 Stock Markets

As mentioned above, both the funding and investment currencies' stock markets are included in my paper. As a result, there are five equity stock market indexes including funding currency stock markets (Japanese Nikkei 225 and US S&P 500) and investment currency stock markets (Australian S&P/ASX 200, New Zealand S&P/NZX 50 and Chinese Shanghai A Share SHASHR). Daily data for each index are collected directly from DataStream, covering an exact examined window as used for currency carry trade. Finally, I calculated daily log returns for all six stock market indexes.

Figure 7 provides a snapshot of cumulative daily stock market performance over the examined period. Noticeably, both the carry trade and stock market plunged in the most downward month of October 2008. All the five examined stock market indexes, especially Chinese SHASHR, suffered hardest hit from the crisis that originally derived from the crash in the US subprime mortgage market. As shown by the King and Wadhwani (1990) model, the downturn overlapping between currency carry trade and stock markets could be understood from a perspective of contagion in financial markets when investors infer information from price changes in other markets and then initiate trading activities in their own investing markets. In particular, financial crisis caused panic among investors and lead to carry trade's unwinding activities while equity investors interpreted the reversals of carry trades as negative events or negative shocks, thereby moving their capital out of the stock markets and flocking to safe haven assets such as Treasury bonds or Japanese yen.

Such process might also be in the reverse direction (from carry trade to stock market) since the interactions between the carry trade and stock market are hard to be directionally measured.

Figure 7: Selected Stock Market Index (July 5, 2006 = 100)



Similar to carry trade returns, stock market returns also had positive mean and negative skewness. The latter, i.e. negative skewness, implies my studied stock markets generated negative returns with greater probability than odds as suggested by a symmetric distribution that has zero skewness characteristic. Negative skewness in stock markets was also reported in Blanchard and Watson (1982) paper in which they attributed the characteristic to the bursting of stock price bubbles or in Hong and Stein (2003) study where the authors assumed short sales constraints limited the market's ability to incorporate bad news; as a result, the price responded to the cumulative effects of bad news and fell sharply. Hence, my result of stock market skewness is consistent with historical findings from prior literatures. Table IV provides summary statistics of daily stock market returns over my examined horizon.

As suggested from table II and IV, in term of magnitude, the skewness of carry trade returns is approximately comparable to the skewness of stock market returns. This attribute is also in

accordance with Brunnermeier et al. (2009) as the authors reported a commensurate skewness between their carry trade portfolios and the US stock market. Therefore, the shared characteristics, such as positive returns and negatively comparable skewness, between the two markets suggest a possible relationship in which the performance in one market could predict the returns of other market or vice versa. The next section will explain the methodologies as used in this paper to test for the possibility of this cross-market linkage.

Table IV: Summary Descriptive Statistics of Stock Market Returns

Statistics	**S&P 500**	**S&P/ASX 200**	**S&P/NZX 50**	**SHASHR**	**NIKKEI 225**
Mean	0.0042644	0.0008200	0.0014417	0.0048578	0.0008453
Max	0.2022	0.2779	0.1303	0.2944	0.2341
Min	-0.3537	-0.3138	-0.1901	-0.3801	-0.5165
Std.	0.0503752	0.0607113	0.036355	0.0925787	0.0685475
Skewness	-1.543648	-0.4266377	-0.9775598	-0.3752943	-1.090061
Kurtosis	9.551283	5.030013	5.929799	3.754297	7.626111

4. Methodology & Hypotheses

4.1 Methodology

As part of my study, I applied the augmented Dickey-Fuller unit root test on the returns that were calculated for different carry trade strategies and equity stock markets. The purpose of the test is to ensure the sustainability and reliability of the regression model (2), as shown below. Table V suggests that all return variables have no unit roots, thus being stationary over my examined window period.

Table V: Unit Root Test Results (1% CV = -3.430)

Stock Market Returns	Test Statistics	Carry Trade Returns	Test Statistics
S&P/ASX 200	-7.162	JPY-AUD	-8.871
S&P/NZX 50	-5.633	JPY-NZD	-8.752
SHASHR	-8.504	JPY-CNY	-8.659
NIKKEI 225	-7.348	USD-AUD	-9.672
S&P500	-9.099	USD-NZD	-10.036
		USD-CNY	-5.885

Note: The null hypothesis is defined as the presence of a unit root and the alternative hypothesis is stationary. If the absolute value of test statistic is greater than 1% critical value (CV) then the null hypothesis is rejected, i.e. the variable is stationary; otherwise, the variable has a unit root.

After conducting the Dickey-Fuller test for all return variables, I used the following regression equation in order to investigate the carry trade effects on stock returns:

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \varepsilon_t, \quad (2)$$

where S_t is the stock market return variable which can be either funding currency stock market or investment currency stock market. C_t is the generic notation of a proxy for carry trade return, which is calculated by using the equation (1). As suggested by several empirical studies such as Christopher et al. (1990) and Chiang et al. (2001), stock returns exhibited GARCH effects. In some cases, the effects tend to disappear when trading volume is included in the variance equation. However, GARCH effects associated with stock returns have been widely accepted by practitioners; hence, I explicitly take into account the effects in the error term ε_t by using the maximum likelihood ratio test to determine the GARCH structure for ε_t.

Table VI: Lags Determination

Panel A: JPY-based Carry Trade		
Stock Market Returns	**Carry Trade Returns**	**Selected Lags (k,m)**
a) Investment Currency Stock Markets versus Carry Trade		
S&P/ASX 200	JPY-AUD	3,4
S&P/NZX 50	JPY-NZD	4,3
SHASHR	JPY-CNY	1,1
b) Funding Currency Stock Markets versus Carry Trade		
NIKKEI 225	JPY-AUD	3,4
NIKKEI 225	JPY-NZD	3,4
NIKKEI 225	JPY-CNY	3,3
Panel B: USD-based Carry Trade		
Stock Market Returns	**Carry Trade Returns**	**Selected Lags (k,m)**
a) Investment Currency Stock Markets versus Carry Trade		
S&P/ASX 200	USD-AUD	3,2
S&P/NZX 50	USD-NZD	4,3
SHASHR	USD-CNY	1,1
b) Funding Currency Stock Markets versus Carry Trade		
S&P 500	USD-AUD	3,2
S&P 500	USD-NZD	3,3
S&P 500	USD-CNY	3,1

Note: There are, in total, 12 regression equations that were estimated. Therefore, 12 corresponding (k,m) pairs were determined as shown in the table.

Moreover, two lag parameters (k and m) had been determined before the equation (2) was estimated. Specifically, parameters were sequentially decided, starting with k and then m. Firstly, k was selected in the absence of C_t variable by considering the Akaike Information Criterion (AIC). The largest lag considered were five. With the already-determined k in place, I moved on with the selection of m by applying the AIC criteria again. The determination process allows the variable β_j to capture the incremental explanatory power that could not be explained in the lag

variables of stock return S_t. Selected lag parameters as used for 12 estimated equations are presented in Table VI.

With lag parameters k and m determined, equation (2) was used to estimate the effects of carry trade returns on its respective funding and investment currencies' stock markets. Basic results are presented in Section 5.

4.2 Robustness Check

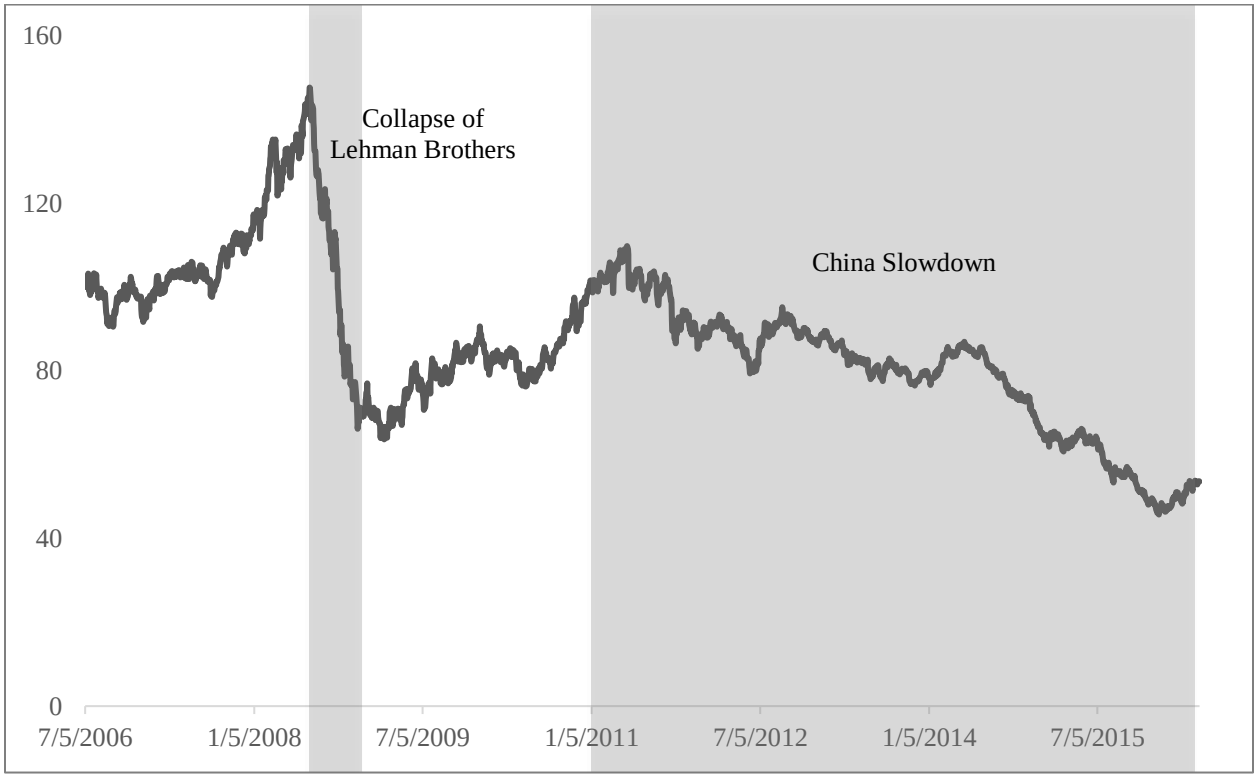
To evaluate the robustness of carry trade effect on stock market, I further add two control variables namely investors' "fear gauge" VIX and Bloomberg Commodity Price, which are believed to have some explanatory power on stock returns, to equation (2). Data on the two indexes were also collected from DataStream.

The CBOE Volatility Index (VIX index) is a key measure of market expectations of near-term volatility conveyed by S&P 500 stock index option prices. Since its inception in 1993, the index has been widely considered as a main gauge of investor sentiment and market volatility. Figure 8 shows the index development over the studied period of this paper. The so-called "fear index" climbed up to high levels in volatile periods such as financial crisis 2008, European sovereign debt crisis 2010 or recent Chinese stock market meltdown and currency devaluation 2015 etc. VIX has also been presented in several prior studies as an explanatory factor for carry trade returns. For example, Brunnermeier et al. (2009) provided evidence that change in VIX index affected carry trade performance, especially in time of high volatility. The authors postulated financial markets' volatility as measured by VIX was state variable that influenced liquidity and risk premium, thus affecting carry trade activities. Moreover, the index has also been used in many papers that look for the factor to explain the stock market performance. Therefore, the inclusion of the "fear" index in equation (3) is expected to provide more powerful result of carry trade effects on stock market performance.

Figure 8: VIX Index Development

Two oceanic countries in my paper, namely Australia and New Zealand, are commonly known as commodity-based economies in which commodity price fluctuations result in large swings of the countries' economic performance. For example, as Australia is a major commodity exporter, commodity prices affect its national income. Rising commodity export prices have been a positive factor for the Australian economy and its stock market performance. Moreover, the Australian dollar is closely linked to commodity price; as a result, a higher (lower) demand of commodity might lead to more (less) demand for the Aussie currency, which indirectly affects the returns of carry trade strategies using Australian dollar as an investment currency. On the other hand, China has been considered as a global consumer of commodities. There has been a clear correlation between Chinese GDP growth and commodity prices. In the early 2000s, when Chinese growth accelerated, commodity prices rose sharply; since China's slowdown began in 2011, energy prices have fallen by 70% and metals prices by 50%. Therefore, I would like to include the effect of commodity prices in my regression equation as an explanatory variable.

Figure 9: Bloomberg Commodity Price Index Development (July 5, 2006 = 100)



With the presence of a control variable, equation (2) is slightly transformed into:

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \gamma_t X_t + \varepsilon_t, \quad (3)$$

where X_t is the generic notation of a control variable, which could be either a change in VIX index or a return on Commodity Price index. The sequential process for lag parameters' determination is similar to the case of equation (2): k was estimated first, then m was determined. However, parameter m for lags of carry trade return was estimated with the presence of not only already-determined lag k of stock return but also the control variable. Therefore, the selection procedure ensures that the β_j-estimates represented the incremental explanatory power of the carry trade variable C_t that is beyond the one found in the lagged values of the stock return and the control variable. For brevity purpose, the result for lag parameters estimated for equation (3) is not shown here but presented in Appendix B.

4.3 Hypotheses

In this study, two hypotheses are proposed in order to examine the interaction between currency carry trade and equity stock markets over the above-mentioned ten-year period. Each of the

ensuing hypotheses is stated in the null format. As discussed in "Literature Review" (Section 2), Cheung et al. (2012) found a positively significant effect of carry trade on its target currency stock markets. The authors cited the liquidity effects created by carry trade activities that leads to asset price inflation, including an increase in stock market. Moreover, according to "flow oriented" model as first discussed by Dornbusch and Fisher (1990), they suggested that exchange rate fluctuations cause movements in stock prices. The rationale is built on the macroeconomic view and "Efficient Market Hypotheses" that since stock price represents the discounted present value of firm's expected future cash flows then any phenomenon that affects its cash flow would be reflected in the stock price if the market is efficient. Therefore, I expect that the carry trade activities would affect the equity stock market performance. My first testable hypothesis is as follows:

$H_0$1a: ***There is a significant positive relationship between carry trade and stock markets of investment (target) currencies.***

$H_0$1b: ***There is a significant negative relationship between carry trade and stock markets of funding currencies.***

As inferred from equation (2) and (3). hypothesis (1a) with stock market of target currency as the dependent variable predicts the parameter β_0 (j = 0) to be positive (greater than zero), which effectively shows a contemporary positive relationship between the two markets. However, hypothesis (1b) predicts the reverse scenario, i.e. parameter β_0 (j = 0) should be negative (less than zero) to exhibit a contemporary negative relationship between currency carry trade and stock markets of funding currencies.

In this paper, two funding currencies namely Japanese yen and US dollar were used to form carry trade strategies. The purpose of using these two currencies is to test the difference in the effects of their carry trade on their respective stock markets, Japanese Nikkei 225 and US S&P 500. As suggested by Fung et al. (2013), the relationship between carry trade and Japanese stock market was significantly positive, which contradicted to conventional explanation that low interest rate environment (such as Japan) would suffer capital outflow; as a result, the country's asset price would decrease. Hence, the second hypothesis follows:

$H_0 2a$*: *There is a significant negative relationship between US dollar-based carry trade and US S&P 500 stock market.

$H_0 2b$*: *There is a significant positive relationship between yen-based carry trade and Japanese Nikkei 225 stock market.

The second hypothesis proposes a positive parameter β_0 found in case the regression equation, either (2) or (3), is used to test the relationship between yen-funded carry trade and Japanese stock market. Conversely, a negative parameter β_0 is expected if the regression equation is used to examine the linkage between dollar-funded carry trade and the US stock market. These expectations reflect the interesting result as cited by Fung et al. (2013) that Japanese yen no longer played a role of funding currency in global carry trade.

The results of my paper are presented in the next section ("Results and Analyses"). The section also verifies the validity of the above-mentioned hypotheses.

5. Results and Analyses

5.1 Preliminary Results

Table VII: Carry Trade Effects Summary

Carry Trade Strategies	*Investment Currency Stock Market*			*Funding Currency Stock Markets*	
	S&P/ASX 200	**S&P/NZX 50**	**SHASHR**	**NIKKEI 225**	**S&P 500**
JPY-AUD					
β_0	**0.208** (15.35)			**0.327** (24.42)	
k, m	3, 4			3, 4	
JPY-NZD					
β_0		**0.077** (12.73)		**0.288** (21.70)	
k, m		4,2		3,4	
JPY-CNY					
β_0			**0.130** (3.24)	**0.434** (13.93)	
k, m			1, 1	3,3	
USD-AUD					
β_0	**0.228** (10.39)				**-0.074** (-4.33)
k, m	3,2				3,2
USD-NZD					
β_0		**0.074** (8.53)			**-0.056** (-3.38)
k, m		4,3			3,3
USD-CNY					
β_0			0.373 (1.65)		0.228 (1.41)
k, m			1,1		3,1

Note: For each carry trade strategy, two regressions are estimated, i.e. one for estimating carry trade effect on investment currency stock market and another for the effect on funding currency stock market. Hence, there are 12 regressions that were estimated in this paper. Regression equation (2) is given again as below:

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \varepsilon_t$$

β_0 is reported as this study only looks at contemporary effects of carry trade on stock markets. It implies that the effects from carry trade activities quickly pass through into equity stock markets. The corresponding t-statistics are in brackets. Bold coefficients represent significance at 1% level.

The results for estimating carry trade effects on the stock markets, i.e. by estimating equation (2), are shown in table VII. As financial research typically reports financial markets' movements across different asset classes at the same trading day, my paper also looks into the simultaneous movements between carry trade and stock market. It effectively implies that stock and currency markets could occur almost instantaneously. Therefore, the main concern of my study is to identify the significance and the sign of β_0 so only β_0 coefficients and their significance are reported in table VII.

Firstly, parameter β_0 estimates from the table indicate significantly positive effects of carry trade returns on investment currency stock markets (as shown by figures in the second column). Except for the USD-CNY strategy, the other five strategies exhibit significant impacts on their respective target currency stock markets (in Australia, New Zealand and China). The significance is inferred directly from the t statistics as shown inside the brackets. For both yen- and US dollar-based strategies, the carry trade effect on investment currency stock markets is highest for Australian stock market, which is suggested by highest and significant coefficients β_0 under the two regression equations using the returns of S&P/ASX 200 as dependent variable (0.208 and 0.228). It effectively means that a change in returns of JPY-AUD or USD-AUD carry trade strategies will have a highest impact on the performance of Australian stock market.

The finding, i.e. positive effects of carry trade on investment currency stock markets, is consistent with the result as suggested by Cheung et al. (2012). The authors conducted an empirical study on the carry trade effects and found significant positive influence on stock returns in Australia, Canada, Britain, Mexico and New Zealand. My result is also partly supported by Fung et al. (2013) as they found that higher carry trade returns led to the substantially improving stock market returns of Australia. Therefore, I can state that there is a significant positive relationship between the profit measures of currency carry trade and stock returns in the corresponding target currency countries, i.e. null hypothesis (1a) is accepted:

$H_0 1a$*: *There is a significant positive relationship between carry trade and stock markets of investment (target) currencies

As UIP is violated, there are more investors participating in carry trade market. As a result, there would be more (less) demand for target (funding) currencies. Under this mechanism, the financial markets of investment or target currencies, typically known as high yielding environments, would

receive capital inflows from investors while their counterparts, typically known as low yielding environments, would suffer capital outflows. Therefore, stock markets of investment currencies are fueled with more invested capital. It implies the push channel effects in which carry trade activities increase liquidity in other asset classes, including stock market, and result in higher price inflations. Another possible explanation relates to the linkage between currency exchange rate movement and stock market. As higher demand for investment currency increases its value relative to other currencies, the stock price would possibly also rise since the value of stock depends on the firm's future expected cash flows that are denominated in the respective currency. Generally, valuable currency would trigger more capital flows into the assets denominated in that currency as investors prefer to possess high value currency assets. Therefore, the capital flow process results in the positive association between carry trade market and stock markets of investment (target) currencies, which is well proven with empirical evidences about "hot money" flows across different markets.

With the above explanations, I expect the reverse effect would apply for stock market returns of funding currencies as their financial markets are thought to suffer capital outflows due to low yielding environments. As a result, my hypothesis (1b) was developed:

$H_0 1b$*: *There is a significant negative relationship between carry trade and stock markets of funding currencies.

However, table VII provides a mixed result so that we could not totally accept the above-mentioned hypothesis. It is found that only US dollar-based carry trade strategies have negative impacts on their funding currency stock market, namely S&P 500. Except for USD-CNY, the other two USD-AUD and USD-NZD carry trades show significantly negative effects on S&P 500 performance (-0.074 and -0.056 respectively). As discussed above, low yielding financial markets of funding currencies encounter a drain of capital, which negatively affects the returns of the respective stock markets. Particularly, the capital is moving away from the low interest rate environment in the US and seeking more attractive financial assets that yield at higher rates. The outflows of capital effectively push down the value of the US stock market, which results in the negative linkage between currency carry trade and S&P 500 returns. Therefore, hypothesis (2a) is accepted:

$H_0 2a$*: *There is a significant negative relationship between US dollar-based carry trade and the US S&P 500 stock market.

Table VII gives an interesting result with respect to Japanese yen-based carry trade strategies. Contradicting to the capital flow explanation that predicts negative effects of carry trade on funding currency stock market, the result shows a significantly positive association between the profit measures of yen-funded carry trade and Japanese stock market Nikkei 225. All β_0 estimates of three carry trade strategies including JPY-AUD, JPY-NZD and JPY-CNY are positively significant at 1% level (0.327, 0.288 and 0.434 respectively). The yen-based strategy in which Chinese renminbi is used as investment currency shows a strongest impact on the performance of Japanese stock market Nikkei 225 as it has a highest coefficient β_0 of 0.434. It means the carry trade JPY-CNY does not necessarily lead to the net capital outflow experienced by Japanese equity market. In fact, Nikkei 225 attracts the "hot money", which is borrowed in yen currency, more than Chinese stock market, thereby resulting in the net inflows to Japanese stocks. This mechanism can be interpreted in the sense that investors have higher confidence on the strong fundamentals of Japan as compared to China. Moreover, the observed positive relationship sheds an interesting difference in the effects of between Japanese yen-based and the US dollar-based currency carry trade on their respective funding currency stock markets, Japanese Nikkei 225 and the US S&P 500 respectively. It also confirms my last null hypothesis (2b):

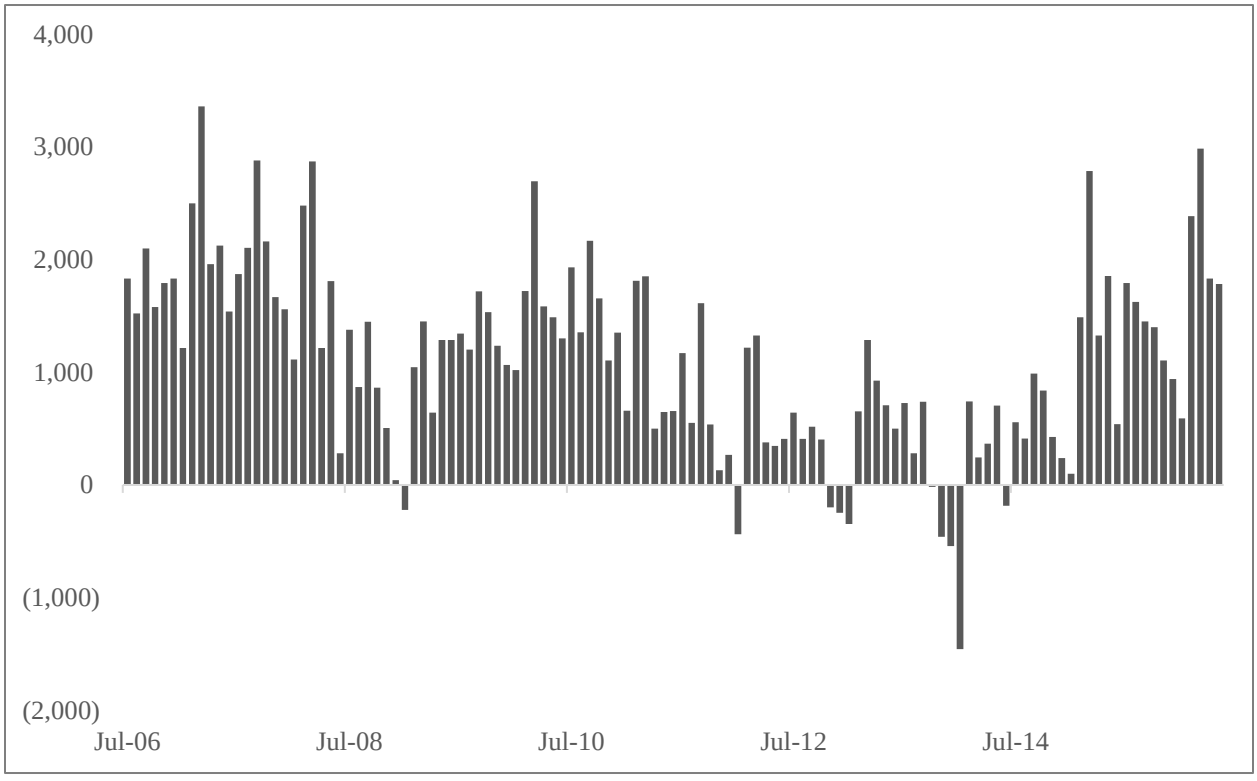
$H_0 2b$*: *There is a significant positive relationship between yen-based carry trade and Japanese Nikkei 225 stock market.

As reported by Fung et al. (2013), the authors found that higher Japanese stock market returns were driven by higher yen-based carry trade returns, indicating a positive association between the two markets. Consistent with their result, my study reaffirms the thought-provoking status of Japanese yen, which has been popularly considered as a funding currency in carry trade transactions. The concept that Japanese yen only plays a funding role in carry trade activities is subject to debate as suggested by my finding. In my opinion, there are two reasons that are able to explain the positive relationship between yen-based carry trade strategies and Japanese stock market.

Firstly, the strengthening of Japanese currency during periods of risk aversion has become so repetitive that results in the perception of the yen as a safe-haven asset among investors. For example, financial crisis fueled the appreciation of the currency by more than 20 percent. Moreover, worries about peripheral European debt led to a 10 percent increase against the shared

currency euro. The safe haven status has been supported by the fact that Japan is a net creditor to the world with current account surpluses lasting for decades. The country's net foreign assets, the difference in the value between foreign assets held by Japanese investors and Japanese assets owned by foreign investors, is substantially high – standing at more than ¥300 trillion (approximately $2.5 trillion) at the end of 2015. When financial markets become volatile for example due to crisis, political unrests or economic shocks, capital tends to flow back to home. The repatriation of money allows the flow into Japan or Japanese yen, boosting the value of the currency as a result. Hence, some investors might perceive the yen as an investment currency rather than a source of borrowed fund and aim to earn substantial returns in time of high volatility. It effectively implies that yen-funded carry trade strategies do not necessarily, as a whole, result in net capital outflows (out of Japan).

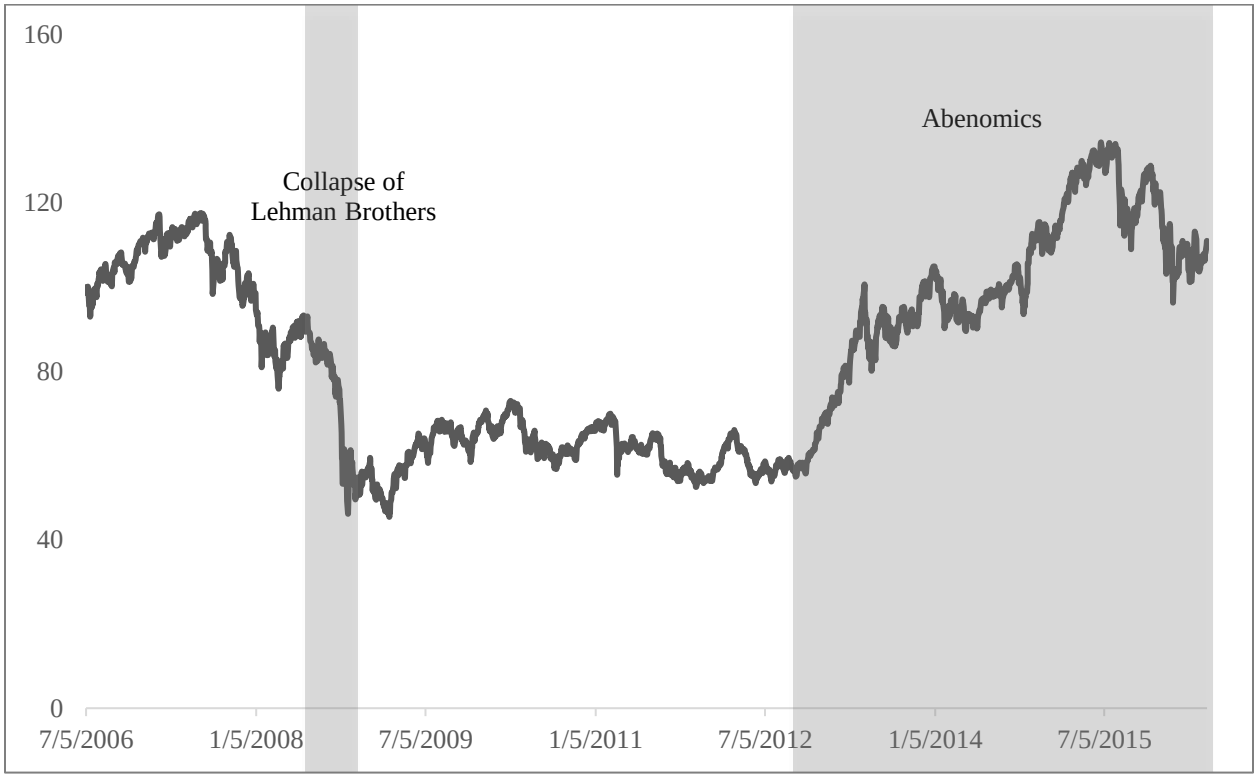
Figure 10: Japanese Current Account (Billion Yen)



Secondly, conventional view that equity stock market of low yielding currency is not a target for carry trade investment is also subject to debate. Traditionally, it has been thought that investors borrow fund from low yielding currencies (such as Japanese yen) and invest the proceeds into assets of high yielding environment, which results in capital outflows of the low yielding countries

(such as Japan); however, this consequence does not happen in case of Japan. As popularly known, quantitative easing (QE) was effectively born in Japan, a country plagued in recent history by deflation and rolling recession. Since 2001, Japan has conducted many qualitative and quantitative (QQE) programs in an effort to stimulate growth and get price rising again. Under the so-called "Abenomics" monetary policies introduced by the end of 2012, the recent easing program was expanded to purchase at the pace of ¥80 trillion of bonds a year starting from October 2014. As can be seen from figure 11, these measures have brought the Japanese stock market stepping out of its trough due to the effects of crisis 2008 and considerably rising over the time. Nikkei 225 index, for example, has increased by almost 150 percent since the beginning of 2009, before experiencing a slight fall recently due to global slowdown and commodity price plunge. Therefore, investors have started to bet on the economic fundamentals in Japan, especially after the financial crisis, as supported by aggressive easing measures by the country's central bank, thereby triggering capital flowing back to the country's equity stock market instead of seeking higher yielding assets in other countries.

Figure 11: Japanese Nikkei 225 Index Development (July 5, 2006 = 100)



Both the reasons provide insights about the different behavior of yen-funded carry trade effects on Japanese stock market. I believe there are some other explanations for this interesting finding, which requires more profound research into the country's institutional framework. In the next section, I would introduce two more control variables, namely "fear gauge" VIX index and Bloomberg Commodity Price, to my regression equation with the purpose of providing more powerful results on the carry trade effects.

5.2 Robustness Check Results

Table VIII provides summary effects of carry trade activities on stock markets performance with the presence of VIX index. Consistent with prior empirical evidences, the fear gauge movements represented negative influences on stock market returns. VIX's estimated parameters γ_t are significantly negative across twelve regressions, indicating that an increase in the index would drive down the stock performance. A surge in VIX exhibits a rise in risk aversion among investors, causing them to flock their capital out of risky investments (for example stocks) and into safe haven assets (for example Japanese yen and government bonds). As a result, stock market suffers capital outflows and decreases.

With the presence of VIX index, there is a slight alteration to the results as found in section 4. Hypothesis (2a), which states there exists a significant association between US dollar-based carry trade and S&P 500 stock market, is no longer accepted as β_0 parameters for the global reserve currency-funded carry trades are not significant. However, the other hypotheses are still valid, i.e. accepted, with the presence of the fear gauge. Although the inclusion of the index helps explain stock market returns, it generally does not change the importance of carry trade activities in accounting for the performance of stock markets. With respect to US dollar-based carry trade impacts on S&P 500 returns, the result changes to insignificant probably because the VIX index is indirectly derived from S&P 500 stock index option prices, thereby representing a major explanatory power on its respective US stock market. Moreover, since the volatility index also explains the carry trade returns as suggested by Brunnermeier et al. (2009), part of the explanatory power of carry trade on S&P 500 is then exhibited within the VIX variable when the fear index is included in the regression equation, thus lowering the significance of the US dollar-based carry trade returns.

The second control variable is Bloomberg Commodity Price index, which is included in the regression equation in order to assess the robustness of the results as shown in section 4. As expected, return in the commodity price index has a significant positive impact on equity stock markets of commodity-based oceanic economies such as Australia and New Zealand. Moreover, the commodity prices also positively affect the returns of the Chinese SHASHR and US S&P 500 stock markets. As suggested by Creti et al. (2013), the positive relationship between commodity and the US stock market was significantly perceived in the post-financial crisis period. Both markets moved upward during episodes of growing world demand for higher risk-return investments. With the presence of the return of the Bloomberg Commodity Price index in the regression model, conclusions made in section 4 are still valid. Table IX shows that there are significantly positive carry trade effects on investment currency stock markets and Japanese Nikkei 225 performance while the significantly negative relationship is observed between carry trade and the US S&P 500 returns.

The result of simultaneous inclusion of both VIX and Bloomberg Commodity Price indexes is not presented here due to spacing conserve. In general, the inclusion almost has no impacts on the significance of the results as presented in section 4. Appendix C, at the end, provides a summary of the carry trade effects on the stock markets with the presence of both indexes.

In summary, table X shows that the presence of control variables, namely VIX and Bloomberg Commodity Price, has a limited impact on the significant effects of carry trade returns on stock market performance. Although the association between the US dollar-based carry trades and S&P 500 market is insignificant with the presence of VIX index, the negative cross-market linkage significantly exists in the case of without control variables and with the presence of Commodity Price. Hence, I believe there still exists a certain degree of relationship between the two markets in the US. As a result, the three interesting findings in my thesis can be summarized as below:

- There is a significant positive relationship between carry trade and stock markets of investment (target) currencies
- There is a significant negative relationship between US dollar-based carry trade and the US S&P 500 stock market
- There is a significant positive relationship between yen-based carry trade and Japanese Nikkei 225 stock market

Table VIII: Carry Trade Effects Summary with Presence of VIX

Carry Trade Strategies	*Investment Currency Stock Market*			*Funding Currency Stock Markets*	
	S&P/ASX 200	**S&P/NZX 50**	**SHASHR**	**NIKKEI 225**	**S&P 500**
JPY-AUD					
β_0	**0.177** (12.02)			**0.305** (23.01)	
γ_t	**-0.001** (-11.57)			**-0.001** (-9.23)	
k, m	3, 4			3, 4	
JPY-NZD					
β_0		**0.066** (10.48)		**0.266** (19.89)	
γ_t		**-0.000** (-10.21)		**-0.001** (-9.89)	
k, m		4, 4		3, 4	
JPY-CNY					
β_0			**0.119** (3.00)	**0.414** (13.30)	
γ_t			**-0.001** (-6.64)	**-0.002** (-15.40)	
k, m			1, 1	3, 3	
USD-AUD					
β_0	**0.215** (10.62)				-0.015 (-1.06)
γ_t	**-0.001** (-11.26)				**-0.003** (-45.16)
k, m	3, 2				3, 2
USD-NZD					
β_0		**0.062** (7.16)			-0.021 (-1.51)
γ_t		**-0.001** (-10.36)			**-0.003** (-41.26)
k, m		4, 3			3, 3
USD-CNY					
β_0			0.332 (1.48)		0.227 (1.98)
γ_t			**-0.001** (-6.89)		**-0.003** (-47.17)
k, m			1, 1		3, 1

Note: Coefficients are reported by estimating the equation (3) as given again below:

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \gamma_t X_t + \varepsilon_t$$

β_0 is reported as this study only looks at contemporary effects of carry trade on stock markets. It implies that the effects from carry trade activities quickly pass through into equity stock markets. The corresponding t-statistics are in brackets. Bold coefficients represent significance at 1% level.

Table IX: Carry Trade Effects Summary with Presence of Commodity Price

Carry Trade Strategies	*Investment Currency Stock Market*			*Funding Currency Stock Markets*	
	S&P/ASX 200	**S&P/NZX 50**	**SHASHR**	**NIKKEI 225**	**S&P 500**
JPY-AUD					
β_0	**0.204** (14.78)			**0.337** (23.77)	
γ_t	**0.012** (2.00)			-0.013 (-1.62)	
k, m	3, 4			3, 3	
JPY-NZD					
β_0		**0.075** (12.44)		**0.295** (21.87)	
γ_t		**0.007** (2.29)		-0.000 (-0.03)	
k, m		4, 2		3, 2	
JPY-CNY					
β_0			**0.133** (3.30)	**0.436** (13.63)	
γ_t			**0.013** (2.10)	**0.035** (5.10)	
k, m			1, 1	3, 3	
USD-AUD					
β_0	**0.216** (9.50)				**-0.101** (-6.17)
γ_t	**0.019** (2.48)				**0.056** (8.03)
k, m	3, 2				3, 2
USD-NZD					
β_0		**0.070** (7.95)			**-0.083** (-5.42)
γ_t		**0.014** (3.54)			**0.054** (8.78)
k, m		4, 3			3, 3
USD-CNY					
β_0			0.367 (1.62)		-0.001 (-0.01)
γ_t			**0.021** (3.29)		**0.055** (8.71)
k, m			1, 1		3, 1

Note: Coefficients are reported by estimating the equation (3) as given again below:

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \gamma_t X_t + \varepsilon_t$$

β_0 is reported as this study only looks at contemporary effects of carry trade on stock markets. It implies that the effects from carry trade activities quickly pass through into equity stock markets. The corresponding t-statistics are in brackets. Bold coefficients represent significance at 5% level.

Table X: Hypothesis Conclusion

Hypotheses	**Accepted**/Rejected		
	Without Robustness	*Robustness - VIX*	*Robustness - Commodity*
$H_0 1a$: *There is a significant positive relationship between carry trade and stock markets of investment (target) currencies*	**Accepted**	**Accepted**	**Accepted**
$H_0 1b$: *There is a significant negative relationship between carry trade and stock markets of funding currencies.*	Mixed	Rejected	Mixed
$H_0 2a$: *There is a significant negative relationship between US dollar-based carry trade and the US S&P 500 stock market.*	**Accepted**	Rejected	**Accepted**
$H_0 2b$: *There is a significant positive relationship between yen-based carry trade and Japanese Nikkei 225 stock market.*	**Accepted**	**Accepted**	**Accepted**

5.3 Additional Results

As mentioned above, my paper solely focuses on the contemporary effects of carry trade on stock market performance, which means the impacts from historical carry trade returns are not considered in investigating the current relationship between the two markets. However, because equity stock market movements can be, sometimes, explained by carry trade performance from the past, I include this section to introduce the total impacts of carry trade transactions on stock returns by taking the lagged effects into consideration. Table XI provides a summary of the effects under three different scenarios including: without control variable, with control variable VIX and with control variable Bloomberg Commodity Price. The effects are shown for all six carry trade strategies and with respect to both funding and investment (target) currency stock markets. Moreover, only significant coefficients β_j (j ranging from 0 to m) are included in the summation $\sum_{j=0,\dots,m} \beta_j$, which is considered as a proxy for the total carry trade effect on the respective stock market.

Table XI: Additional Results from Carry Trade Lags

Panel A (Without Control Variable):

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \varepsilon_t$$

Japanese yen-based Carry Trade Strategies			**US dollar-based Carry Trade Strategies**		
Dependent Variables	*Carry Trade & Lags*	$\sum_{j=0,\dots,m} \beta_j$	*Dependent Variables*	*Carry Trade & Lags*	$\sum_{j=0,\dots,m} \beta_j$
S&P/ASX 200	JPY-AUD	-0.0023	S&P/ASX 200	USD-AUD	0.0163
S&P/NZX 50	JPY-NZD	0.0231	S&P/NZX 50	USD-NZD	0.0296
SHASHR	JPY-CNY	0.1303	SHASHR	USD-CNY	N/A
NIKKEI 225	JPY-AUD	0.0736	S&P 500	USD-AUD	0.0389
NIKKEI 225	JPY-NZD	0.1139	S&P 500	USD-NZD	0.0225
NIKKEI 225	JPY-CNY	0.1273	S&P 500	USD-CNY	N/A

Panel B (With Control Variable VIX):

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \gamma_t X_t + \varepsilon_t$$

Japanese yen-based Carry Trade Strategies			**US dollar-based Carry Trade Strategies**		
Dependent Variables	*Carry Trade & Lags*	$\sum_{j=0,\dots,m} \beta_j$	*Dependent Variables*	*Carry Trade & Lags*	$\sum_{j=0,\dots,m} \beta_j$
S&P/ASX 200	JPY-AUD	-0.0332	S&P/ASX 200	USD-AUD	-0.0646
S&P/NZX 50	JPY-NZD	0.0081	S&P/NZX 50	USD-NZD	0.0001
SHASHR	JPY-CNY	0.0381	SHASHR	USD-CNY	N/A
NIKKEI 225	JPY-AUD	0.0422	S&P 500	USD-AUD	0.0099
NIKKEI 225	JPY-NZD	0.0754	S&P 500	USD-NZD	0.0185
NIKKEI 225	JPY-CNY	0.1586	S&P 500	USD-CNY	0.2744

Panel C (With Control Variable Bloomberg Commodity Price):

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \gamma_t X_t + \varepsilon_t$$

Japanese yen-based Carry Trade Strategies			**US dollar-based Carry Trade Strategies**		
Dependent Variables	*Carry Trade & Lags*	$\sum_{j=0,\dots,m} \beta_j$	*Dependent Variables*	*Carry Trade & Lags*	$\sum_{j=0,\dots,m} \beta_j$
S&P/ASX 200	JPY-AUD	0.0003	S&P/ASX 200	USD-AUD	-0.0013
S&P/NZX 50	JPY-NZD	0.0214	S&P/NZX 50	USD-NZD	0.0221
SHASHR	JPY-CNY	0.1326	SHASHR	USD-CNY	N/A
NIKKEI 225	JPY-AUD	0.1024	S&P 500	USD-AUD	-0.0035
NIKKEI 225	JPY-NZD	0.0727	S&P 500	USD-NZD	-0.0104
NIKKEI 225	JPY-CNY	0.1456	S&P 500	USD-CNY	N/A

Note: Only significant coefficients β_j (at 5% level) are included in the sum $\sum_{j=0,\dots,m} \beta_j$. N/A means not available due to insignificance of coefficients

Under the first scenario when there is no presence of the control variable, the overall effects of carry trade on investment currency stock markets are mostly positive, except for JPY-AUD strategy. This result, to some extent, confirms the positive association between currency carry trade and stock market returns of investment currencies that I highlight earlier. Considering the lagged effects also results in the positive relationship between Japanese-based carry trades and their funding currency stock market Nikkei 225, which is similar to my accepted hypothesis $H_0 2b$. However, hypothesis $H_0 2a$ no longer be accepted if the overall effect is taken into account. Specifically, there is a positive linkage between US dollar-based carry trades and their funding currency stock market S&P 500, instead of a negative relationship that I conclude in section 5.1 ("Preliminary Results"). Although this difference is interesting to investigate, it is beyond the scope of my studied interest, i.e. the contemporaneous effects of carry trade on equity stock markets.

With the presence of the control variable, either VIX or Bloomberg Commodity Price, the positive relationship between yen-funded carry trade strategies and Nikkei 225 performance still holds while the positive relationship between carry trade and investment currency stock market is slightly affected, especially when the fear gauge is included in the regression equation. Particularly, the sign of $\sum_{j=0,\dots,m} \beta_j$ for USD-AUD turns to a negative figure (-0.0646) from a positive figure (0.0163) as found without the presence of the control variable VIX, which implies a negative relationship between the carry trade strategy USD-AUD and its investment currency stock market S&P/ASX 200. In summary, the presence of the VIX lowers the credibility of the positive effects of carry trade transactions on the performance of investment currency stock market returns. Moreover, it is important to notice that the presence of Bloomberg Commodity Price index confirms the three findings as detailed in section 5.1 ("Preliminary Results"). Table XII below illustrates the validity of my proposed hypotheses when the lagged effects of carry trade returns are taken into consideration. Although the results from table XII display certain degrees of variations to the three conclusions that I made earlier, they also confirm the majority of the carry trade effects that I propose under the three conclusions. Therefore, my three results still hold, especially when the major focus of this paper is to study the contemporary effects of carry trade on the stock market performance.

Table XII: Hypothesis Conclusion with Lagged Effects of Carry Trades

Hypotheses	**Accepted**/Rejected		
	Without Robustness	*Robustness - VIX*	*Robustness - Commodity*
$H_0 1a$: *There is a significant positive relationship between carry trade and stock markets of investment (target) currencies*	**Accepted**	Mixed	**Accepted**
$H_0 1b$: *There is a significant negative relationship between carry trade and stock markets of funding currencies.*	Rejected	Rejected	Mixed
$H_0 2a$: *There is a significant negative relationship between US dollar-based carry trade and the US S&P 500 stock market.*	**Accepted**	Rejected	**Accepted**
$H_0 2b$: *There is a significant positive relationship between yen-based carry trade and Japanese Nikkei 225 stock market.*	**Accepted**	**Accepted**	**Accepted**

6. Conclusion

Currency carry trade is a widely adopted trading strategy that sells a certain currency with a relatively low interest rate and uses the funds to purchase a different currency yielding at a higher interest rate. Moreover, carry trade is popular among not only individuals but also institutional investors, especially hedge funds. Currency carry trade market is estimated to worth at multi-trillion dollar, which is relatively in the same size of Japanese gross domestic product (GDP). On average, the strategy yields moderately high returns in normal periods; however, it shows dramatic losses during turbulent periods. In times of heightened volatility, lower interest rate currencies offer insurance because their exchange rate appreciates in response to adverse global shocks, which thus causes huge damage to carry trade investors. Therefore, volatility is believed to well explain the returns from the so-called UIP exploitation strategy, as also shown in Menkhoff et al. (2012) where the authors found that more than 90 percent of the cross-sectional excess returns was explained by foreign exchange (FX) volatility.

The carry trade market is closely linked with equity markets through global capital flows. In my paper, I investigate the implications of currency carry trade activities on the performance of funding and investment currency stock markets. As an extension from prior papers that mainly focused on Japanese yen carry trade and its effects on target currency stock markets, my study additionally includes US dollar as a possible funding currency and examines the impacts of the trading strategy on stock markets of not only investment currencies but also funding currencies. Moreover, the inclusion of Chinese renminbi into the investment currency basket differs my work from others due to their negligence of the currency's attractive qualities such as high yielding rate and appreciating value over the time.

Using a daily data from July 5, 2006 to May 31, 2016, I test the relationship between currency carry trade and its corresponding stock markets. Carry trade return is calculated as the difference between future realized spot exchange rate and current forward rate for one period. The returns data are measured for six carry trade strategies as formed by two funding currencies (Japanese yen and the US dollar) and three investment currencies (Australian dollar, New Zealand dollar and Chinese renminbi). The stock markets from corresponding carry trade currencies namely Nikkei 225, S&P 500, S&P/ASX 200, S&P/NZX 50 and SHASHR are chosen as proxies for equity markets. In order to investigate the relationship between two markets, I use the regression equation

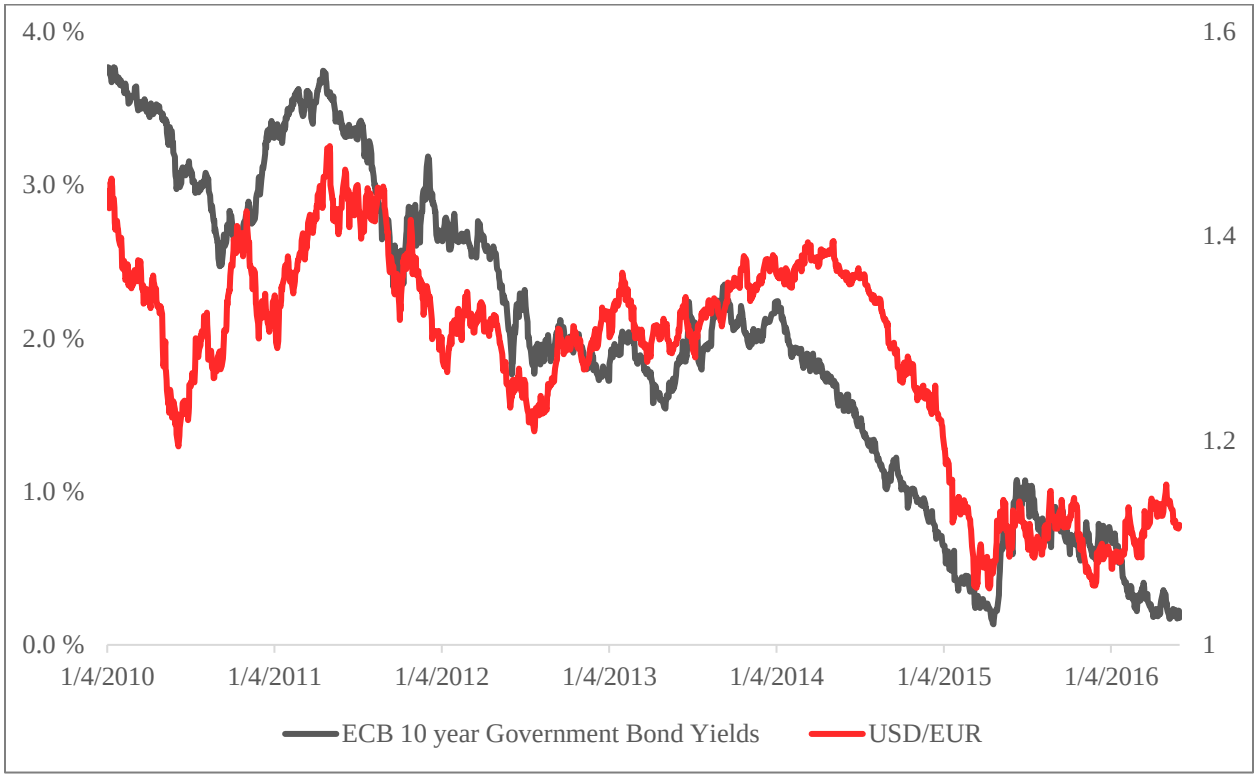
with equity market returns and carry trade returns as dependent and independent variables, respectively. Moreover, GARCH effects are considered in the estimated equations' error terms to explain stocks' clustered performance behaviors. I also add few explanatory factors, namely VIX and Bloomberg Commodity Price indexes, to assess the robustness of carry trade effects on stock market performance.

Three interesting results are reported in this paper. First, both the yen-based and US dollar-based carry trade returns have positive impacts on investment currency stock markets, i.e. a rise or fall in carry trade performance results in a similar move for its related stock market of target currency. Mechanism, as created by carry trade activities, moves capital out of low yielding environment of funding currency and into high yielding environment of investment currency, which effectively increases the liquidity of target country's stock market and leads to price inflation. This process was described as "push channel" effects in Cheung et al. (2012) where the authors also found significantly positive associations between yen carry trade and stock returns in target currency countries. Secondly, capital flow explanations predict a reverse scenario, i.e. negative relationship, between carry trade and stock returns in funding currency countries. However, this effect can only be found with respect to the US dollar-based strategies in my paper. The second interesting finding suggests a negatively significant association between the profit measure of carry trade activity and the US stock market return. In order to combat the adverse effects triggered by the subprime financial crisis, the US government adopted an aggressive monetary policy that lowered the policy rate to zero percent, thus propelling an attractive dollar-funded carry trade strategies. As a result, these carry trade activities are expected to result in capital outflows that lead to the negative relationship between currency carry trade and the US stock market returns, especially in post crisis period. Finally, the most interesting result relates to the cross-market linkage between Japanese yen carry trade and Nikkei 225 stock market returns. In my study, it is found that there is positively significant association between yen-funded carry trade and Japanese stock market performance. It is contradicting to conventional theory that expects a negative relationship between the two markets due to capital outflows experienced by Japan. This finding supports the result as suggested by Fung et al. (2013) that carry trades also participate in betting on strong economic fundamentals in Japan, indicating Japanese yen no longer plays the only role as a funding currency in carry trade transactions. Therefore, the effects of yen-based carry trade strategies on Japanese stock market differs from the traditional view.

With the presence of some control variables such as VIX financial markets volatility index or Bloomberg Commodity Price index, the impacts on the significance of carry trade effects are limited even though these indexes, to some extents, are proved to have some explanatory powers on stock market returns. More noticeably, the negatively significant relationship between the US dollar-based carry trade and S&P 500 performance no longer exists when I include the change in the "fear gauge" index, i.e. VIX, in the regression equation. The wiping out of significance is partly attributed to the fact that the VIX is inherently built on the movements of S&P 500 index; hence, market fear gauge effectively displays a powerful explanation on the US stock market returns, which then decreases the explanatory power from carry trade effects. In summary, the carry trade activities exhibit certain degrees of influences on stock market returns even with the presence of the above-mentioned control variables.

Since 2014, the shift to the euro as a funding currency for carry trade began to take shape since investors expected that European Central Bank (ECB) would soon introduce more monetary stimuli to boost flagging economic growth. With the euros at near zero rates and likely to depreciate due to aggressive easing, the currency has been well qualified as a funding currency used in carry trade transactions. Specifically, there are some evidences supporting the scenario for euro-funded carry trade, for example the currency's counter-intuitive behavior during the Greek turmoil in the mid-year of 2015. The single currency, as shared by 19 of the European Union's Member States, fell when there looked to be progress and gained on bad news. This is because the euro-funded carry trade investment strategy. When the Greek news was good, risk appetite increased and induced investors to borrow low yielding euros to fund bets abroad, making the shared currency fall. However, when risk appetite subdued due to high volatility, the money came back to home countries, i.e. Europe, helping the euro increase. Therefore, I believe aggressive monetary measures as conducted by ECB have propelled euro carry trade activities and thus implanting certain effects on global stock market performance. As my current study solely concentrates on the effects as generated from Japanese yen-based and the US dollar-based carry trade strategies, it will be the interest of my future research to consider the euro into funding currency basket to investigate the cross-market relationship between currency carry trade and equity stock market.

Figure 12: Decreasing Government Bond Yields and Exchange Rate



Appendix A

Interest Parities and Carry Trade Return Formula

The covered interest parity condition is based on no arbitrage condition and is given by:

$$\frac{F_{t,t+1}(1+i^*_{t,t+1})}{E_t} = 1 + i_{t,t+1},\ where:$$

$F_{t,t+1}$: forward rate for one period ahead t + 1 quoted at time t

$i^*_{t,t+1}$: foreign currency interest rate for the period between t and t + 1

$i_{t,t+1}$: domestic currency interest rate for the period between t and t + 1

E_t: spot exchange rate at time t – number of local currency per a unit of foreign currency

Rearranging the terms, we have:

$$\frac{F_{t,t+1}}{E_t} = \frac{(1+i^*_{t,t+1})}{(1+i^*_{t,t+1})}$$

Using the log approximation, the above equation is transformed as:

$$f_{t,t+1} = e_t - \left(i^*_{t,t+1} - i_{t,t+1}\right),$$

where a lower case letter is the log of the corresponding upper case letter.

Moreover, the uncovered interest parity is given by:

$$E_t e_{t+1} = e_t - \left(i^*_{t,t+1} - i_{t,t+1}\right),$$

where E_t is expectation operator.

Therefore, the realized profit of carry trade - borrowing local currency and lending foreign currency - under the covered interest parity is given by the formula:

$$\pi_{t+1} = e_{t+1} - \left[e_t - \left(i^*_{t,t+1} - i_{t,t+1}\right)\right] = e_{t+1} - f_{t,t+1} = e_{t+1} - E_t e_{t+1}$$

In summary, carry trade return is the deviation from UIP condition, i.e. the error of using forward rate to predict the future spot exchange rate or the difference between current expectation of future spot exchange rate and the realized spot exchange rate in future.

Appendix B

Lags Determination for Robustness Equation

Panel A: JPY-based Carry Trade			
Stock Market Returns	**Carry Trade Returns**	**Selected Lags (k, m) – With VIX**	**Selected Lags (k, m) – With Commodity**
c) Investment Currency Stock Markets versus Carry Trade			
S&P/ASX 200	JPY-AUD	3,4	3,4
S&P/NZX 50	JPY-NZD	4,4	4,2
SHASHR	JPY-CNY	1,1	1,1
d) Funding Currency Stock Markets versus Carry Trade			
NIKKEI 225	JPY-AUD	3,4	3,3
NIKKEI 225	JPY-NZD	3,4	3,2
NIKKEI 225	JPY-CNY	3,3	3,3
Panel B: USD-based Carry Trade			
Stock Market Returns	**Carry Trade Returns**	**Selected Lags (k, m) – With VIX**	**Selected Lags (k, m) – With Commodity**
c) Investment Currency Stock Markets versus Carry Trade			
S&P/ASX 200	USD-AUD	3,2	3,2
S&P/NZX 50	USD-NZD	4,3	4,3
SHASHR	USD-CNY	1,1	1,1
d) Funding Currency Stock Markets versus Carry Trade			
S&P 500	USD-AUD	3,2	3,2
S&P 500	USD-NZD	3,3	3,3
S&P 500	USD-CNY	3,1	3,1

Note: As only one control variable (VIX or Bloomberg Commodity Price) is included in the robustness equation, lag parameters (k and m) have to be estimated for two cases – either with the presence of VIX index or with the presence of Bloomberg Commodity Price. Both control variables were not simultaneously included in the regression equation.

Appendix C

Carry Trade Effects with Presence of VIX and Commodity Price

Carry Trade Strategies	*Investment Currency Stock Market*			*Funding Currency Stock Markets*	
	S&P/ASX 200	**S&P/NZX 50**	**SHASHR**	**NIKKEI 225**	**S&P 500**
JPY-AUD					
β_0	**0.177** (11.94)			**0.309** (23.31)	
γ_{1_t}	**-0.001** (-11.49)			**-0.001** (-9.56)	
γ_{2_t}	0.001 (0.12)			**-0.023** (-2.94)	
JPY-NZD					
β_0		**0.066** (10.46)		**0.269** (20.02)	
γ_{1_t}		**-0.000** (-9.98)		**-0.001** (-10.20)	
γ_{2_t}		0.002 (0.07)		**-0.019** (-2.66)	
JPY-CNY					
β_0			**0.117** (2.93)	**0.415** (13.28)	
γ_{1_t}			**-0.001** (-6.08)	**-0.002** (-14.51)	
γ_{2_t}			-0.006 (-0.83)	0.007 (1.06)	
USD-AUD					
β_0	**0.212** (9.95)				**-0.033** (-2.32)
γ_{1_t}	**-0.001** (-11.08)				**-0.003** (-45.38)
γ_{2_t}	0.006 (0.74)				**0.044** (7.54)
USD-NZD					
β_0		**0.061** (6.88)			**-0.028** (-2.12)
γ_{1_t}		**-0.000** (-9.74)			**-0.003** (-41.59)
γ_{2_t}		0.006 (1.61)			**0.033** (6.45)
USD-CNY					
β_0			0.332 (1.47)		0.226 (1.64)
γ_{1_t}			**-0.001** (-5.34)		**-0.003** (-44.73)
γ_{2_t}			0.001 (0.07)		**0.030** (6.01)

Note: Coefficients are reported by estimating the equation as given again below:

$$S_t = Constant + \sum_{j=1,\dots,k} \alpha_j S_{t-j} + \sum_{j=0,\dots,m} \beta_j C_{t-j} + \gamma_{1_t} X_{1_t} + \gamma_{2_t} X_{2_t} + \varepsilon_t$$

γ_{1_t} and γ_{2_t} are estimated parameters of change in VIX and commodity price return at time t. The corresponding t-statistics are in brackets. Bold coefficients represent significance at 5% level.

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